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HYBRID SWEET CORN

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Standard succession of sweet corn hybrids maturing over a period of approximately a month. Left to right, Spancross C13.4, Marcross, Lexington, Carmelcross, Lee, Lincoln, Golden Cross Bantam, Ioana, Wilson, Golden Greencross C53.65.

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W. Ralph Singleton

Numerous changes have taken place in the sweet corn hybrid picture since Station Bulletin 361, "Crossed Sweet Corn"(1), appeared in 1934. Since then three Circulars, No. 112, "Sweet Corn Inbreds"(2) ; No. 138, "Early Sweet Corn Hybrids, Spancross, Marcross and Carmelcross"(3), and No. 148. "Sweet Corn Hybrids, Lexington, Lincoln and Lee"(4), have helped to present some of the newer developments in sweet corn. However, no comprehensive treatment of the hybrids developed by the Connecticut Station has appeared since 1934.

An excellent bulletin was published by W. D. Enzie (5) of the New York State Agricultural Experiment Station (Geneva) in 1943 that describes the yellow sweet corn hybrids then grown. This bulletin, No. 705, is well illustrated and contains accurate descriptions and much valuable information regarding hybrids then grown. Plates I and II of this bulletin illustrate the different early hybrids, 14 in all. It is interesting that all 14 of those hybrids have Connecticut 13 as one parent.

Since there are several new hybrids and inbreds that have not been completely described, even in our annual mimeographed sweet corn reports, it seems appropriate at this time to attempt to bring up to date all the pertinent information regarding Connecticut sweet corn hybrids.

HISTORICAL COMMENTS

Perhaps no bulletin on hybrid sweet corn or hybrid corn in general would be complete without a paragraph or two on the history of this agricultural phenomenon. Sweet corn hybrids as we know them today are largely single crosses, made by cross pollinating two distinct inbreds, or comparatively pure lines. The method for such seed production was described in a brief but classic article just 39 years ago. The article was "A Pure Line Method in Corn Breeding" by George Harrison Shull(6), then at Cold Spring Harbor, New York.

It outlines almost exactly the method in use in hybrid sweet corn seed production today. The only modification is that now three or four seed rows are grown for each pollen row instead of one as suggested almost four decades ago. The principle, however, remains the same. The sweet corn inbreds so far developed have been sufficiently productive to insure the success of the pure line method almost exactly as Shull proposed it.

From some of the historical accounts of hybrid corn one is apt to get the impression it is the *crossing* or the *hybridization* that accounts for the phenomenon of hybrid corn. If such were the case, it would make little difference whether pure lines or open pollinated varieties were crossed. If this were true, credit for the origin of hybrid corn should go to William James Beal who first crossed different open pollinated varieties of corn in 1881 for the sole purpose of increasing yields by planting the crossed seed (7). Here, then, was the first hybrid corn if the superiority of hybrid corn is in the hybridization.

However, it is the pure line method that has made hybrid corn so

Figure 1. Marcross hybrid sweet corn seed production crossing plot illustrating pure line method in corn breeding. Detassled rows are C13, pollen rows are C6.

successful in the last two decades. Without pure lines there is only limited control over the heredity, whereas with pure lines control is at a maximum. Although others, particularly Edward M. East of this Station, had produced corn inbreds before Shull, it was clearly Shull who first advocated the use of pure lines in the commercial production of seed corn. Consequently, we believe that credit for the pure line method in corn breeding, on the basis of priority of publication, belongs to Shull alone.

Pure Line Method Proposed 39 Years Ago

One paragraph of Shull's 1909 paper impresses us so much with its importance 39 years later that we wish to quote it:

"In the pure line method outlined below all individuals in the field will be F_1 hybrids between the same two homozygous strains, and there are theoretical grounds for expecting that both in yield and uniformity superior results should be secured. Thus every individual will be as complex as every other one and should produce an equal yield of grain if given an equal environmental opportunity, so that in so far as hereditary influences are concerned *the vigor of the entire crop should be equal to the best plants produced by the methods now in use.* This would seem to result necessarily in a larger yield than can be produced by the present method. But not only will all the plants in the field have the same degree of complexity, but will all be made up of the same combination of hereditary elements, *and consequently there must result such uniformity as is at present unknown in corn.*" (Italics ours).

The secret of hybrid corn is contained in this one paragraph. Hybrid corn does not produce bigger or better ears than the best open pollinated corn; it simply produces a greater proportion of such ears. The uniformity mentioned by Shull is one of the reasons why sweet corn growers accepted

hybrid sweet corn so eagerly. Both the growers of market sweet corn and corn for canning want a variety that ripens all at one time. Some of the best market growers pick a field only once. They get 80-90 per cent of the crop in one picking and feel they cannot afford to return to the field for what is left. Other growers may make two pickings but not more. Such a method of harvesting was impossible with the open pollinated varieties and would scarcely be possible with double crosses so widely used in field corn production. It was the uniformity of desirable plant and ear characteristics resulting from crossing *pure lines* that established hybrid sweet corn before hybrid field corn.

OBJECTIVES AND SCOPE OF THE CONNECTICUT BREEDING PROGRAM

Every breeding program must have certain objectives or goals if success is to be achieved. These objectives may change or become clarified in the course of the project. One important objective of the early sweet corn breeding at the Connecticut Station was to determine whether the pure line method was feasible and practical. This breeding work was started by Dr. D. F. Jones in the early 1920's, shortly after he had developed the double cross method for field corn production. This early breeding work was described in Bulletin 361(1) and need not be discussed here in much detail. Some of the open pollinated varieties worked with were Stowells Evergreen, Golden Bantam, Crosby and Whipple's Early Yellow. The first hybrid sweet corn was

Figure 2. Redgreen variety showing uniformity and productivity of hybrid sweet corn.

Redgreen, a cross of a Stowells Evergreen inbred C77 with C75, an inbred that resulted from genetic studies begun by Dr. E. M. East. Redgreen was introduced in 1924. It was a productive hybrid of good quality but was limited in its adaptation and was never widely used. Although it indicated clearly the possibilities of and aroused much interest in the pure line method of breeding, it did not clearly establish the superiority of this method.

Breeding Program to Develop Productive Midseason Hybrid

In 1924 the first self pollinations were made on a number of plants of Whipple's Early Yellow, a midseason large-eared sweet corn then commonly grown. These were in the third generation of inbreeding when the writer joined the staff of the Connecticut Station in 1927. One of our duties that year was to make self pollinations on those inbred Whipple lines; a few crosses were made for testing in 1928. After a few years of testing the best of the Whipple crosses was apparently the hybrid combination 474-2 x C2. It was to be released in 1934 under the name of Gold Cross. However, in 1933 the inbred 474-2 proved to be completely susceptible to an epidemic of bacterial wilt and was discarded. About that time Golden Cross Bantam was introduced by Dr. Glenn M. Smith of the Indiana Experiment Station and the United States Department of Agriculture(8). Consequently, it seemed inadvisable to call a Connecticut hybrid Gold Cross, a name so similar to Golden Cross Bantam. Thus, the bacterial wilt epidemic wiped out one of the parents of the proposed new "Gold Cross" while the introduction of Golden Cross Bantam ruled out the name.

The hybrid Golden Cross Bantam proved to be practically immune to bacterial wilt and was unusually productive. These factors, together with excellent quality, soon established Golden Cross Bantam as the most popular of all varieties, either hybrid or open pollinated. In 1935, three years after its introduction, more than one million pounds of seed were produced and it has remained the leading sweet corn variety until the present time. In 1946 more than five million pounds of seed were produced. It established without a doubt the superiority of the pure line method of producing sweet corn seed. Hence, one of the objectives of our breeding program was achieved, not by our own program but by another plant breeder.

Breeding to Develop Early Wilt Resistant Hybrid

The popularity of Golden Cross Bantam increased rather than lessened the demand for other hybrids. Particularly needed were varieties with the resistance to bacterial wilt of the Golden Cross Bantam, but which would mature earlier in the season. Thus, a new breeding objective emerged.

Since all the sweet corn grown commercially in Connecticut is for market and not for processing, it is essential to learn the needs of the market gardener and try to produce something to meet these specifications. This information would be most valuable if obtained from the growers themselves and was so procured. The market gardener wants as large an ear as possible in the shortest possible time, since the early sweet corn usually commands the highest price and the consumer buys corn by the dozen and selects the larger ears.

To be productive, a hybrid must be resistant to bacterial wilt, smut and other diseases. The wilt epidemic which eliminated the inbred 474-2 brought out the resistance of two other inbred lines, C6, a Whipple line, and C13, an

inbred out of Golden Early Market. Both of these are almost immune to bacterial wilt. These two inbreds when crossed produced a hybrid, early in maturity, productive and wilt-resistant. This hybrid was named Marcross and introduced in 1937.

By 1940 more than one half million pounds of seed were produced and by 1944 the volume had reached one million pounds, not as phenomenal a rise as Golden Cross Bantam but once again confirming the superiority of the pure line method of seed production. Marcross is still the leading variety in its maturity season, being grown more than all other varieties in that class. The quality is not as good as we should like and we have been working to improve or replace it.

Figure 3. Pocahontas C3.8, early home garden variety.

Breeding for a Sweet Corn Succession

While developing Marcross and observing the various inbreds and hybrids in trial we were much impressed with the remarkable differences in maturity in sweet corn inbreds. C4, an inbred out of Spanish Gold, was very early while others such as C77, a white Stowells Evergreen inbred, was rather late. There were others more or less intermediate. It became apparent that by utilization of the proper inbreds it should be possible to produce a series of sweet corn hybrids that would ripen in succession for a period of approximately a month. The first three hybrids in this series, Spancross, Marcross and Carmelcross, were described in 1939 in Station Circular 138(3). These ripen in southern Connecticut at about four-day intervals in the order named. Each of these hybrids has as one parent C13, the wilt resistant inbred secured by inbreeding Golden Early Market. There was an element of luck in the production of C13 since this inbred was one of a total of only 18 original lines selfed the first time in 1931. C13 is used in practically all of the early sweet corn hybrids produced either by the various experiment stations or commercial seedsmen. We know of no productive, early, disease resistant market corn that does not have C13 as one parent.

Lincoln and Lee, two midseason hybrids, were announced in 1941 in Circular 148(4). These two hybrids met the need for market hybrids maturing before Golden Cross Bantam. By the use of either of these two hybrids in conjunction with the three early ones named previously and followed by

Figure 4. Improved Spancross C13.3, earlier and better quality than old Spancross C13.4.

Figure 5. Improved Spancross C12.3 similar to C13.3. Inbred C12 slightly better than C13.

Golden Cross Bantam and Wilson or Magnagold, a fairly good succession of sweet corn can be secured.

One lack of this succession has been a variety maturing between Carmelcross and Lee or Lincoln. A new variety Grant (C22.27) has been added to meet the need for a variety ripening in this season so the succession is almost complete. The addition of two late dependable hybrids described later in this bulletin will provide more productive hybrids in the late season. This succession now includes the following varieties ripening in the order listed: Spancross, Marcross, Carmelcross, Grant, Lee or Lincoln, Golden Cross Bantam, Pershing (C68 x Oh55), and Brookhaven (C53 x Oh55). This succession is designed largely for the market gardener. A comparable succession could be developed for the home gardener who wants the best in quality regardless of the size of ear. Almost enough hybrids are now available for

such a succession. Considerable time and effort could be devoted to making improvements in the market garden succession listed above, but as a project it may be considered complete.

Research to Determine How Much Inbreeding Necessary Before Crossing

Another objective in our breeding program was to determine, if possible, in what generation of selfing it is possible and feasible to test for combining ability. Our results indicate it is probably inadvisable to make crosses of inbreds until they have been selfed three times. Results of this experiment are given in Bulletin 490(9). During the course of this experiment the Whipple inbreds C23 and C27 were developed. These, when crossed by P39, produced Lincoln and Lee, respectively. The most successful Experiment Stations are those that solve practical problems by doing basic research that advances the frontiers of knowledge. Thus, in the process of obtaining information regarding the riddle of hybrid vigor, two productive market garden hybrids were developed. With an abundance of good hybrids, it hardly seems advisable for a plant breeding department of a public institution to continue to develop varieties with that as the prime objective, unless there are no satisfactory hybrids available in a given area, as was the case when hybrid corn was new. This is still true in some sections of the country. In such cases developing good hybrids is a legitimate objective of a breeding program.

Investigation of Vigor in Line Crosses

Another objective of our breeding program has been the investigation of the hybrid vigor that occurs when two sub-lines of the same inbred are crossed(10). A preliminary report of this work was given at the meeting of the American Society of Agronomy at Columbus. Ohio, February 27, 1946(11). The abstract prepared for this paper summarizes the information for line crosses and will be repeated here.

"Recent researches have demonstrated a remarkable amount of hybrid vigor when two sub-lines of the same inbred are crossed. This hybrid vigor occurs in lines that have been separated after they have supposedly been reduced to homozygosity by inbreeding. One explanation for this hybrid vigor may be that the original line was not homozygous and that the factors for heterosis segregated in the sub-lines and were manifest when the sub-lines were crossed. Another explanation is that the inbreds have mutated to new heterotic factors that become manifest upon crossing. The mutation rate for such factors need not be higher than for factors for morphological characters since mutations can arise at any one of perhaps several thousand loci. Whatever the explanation, it is possible to make use of this intra-inbred vigor in maize breeding. The hybrid of P39 with the mutant C30 derived from it yields in some cases 30 per cent more than P39. By using the P39 x C30 cross as a seed parent in crossing plots instead of P39, seed yields can be increased and also a little better quality of seed can be secured, since the ears and seeds are slightly larger. Preliminary tests have shown that P39.C30 x C42 is fully as productive as either P39 x C42 or C30 x 42 and the variability of P39.C30 x 42 is no greater than either single cross. Other line crosses tested in 1945 were C31-1.31-2 x 88 and a cross of two sub-lines of P39 x C23 in comparison with the commercial Lincoln P39 x C23. In both cases the variability of the line crosses was no greater than for single crosses. Thus, it seems feasible in sweet corn production, at least, first to make crosses

within the line used as a seed parent and then use this line cross as the seed parent. In field corn similar line crosses are now being used as pollinators. It may be possible to use them as seed parents also to produce essentially a single cross instead of the double cross now in use."

Figure 6. Line cross of P39M92, left, P39M92 x C30 and C30, right, showing vigor of line crosses.

Our investigations have not revealed just which sub-lines of Purdue 39 make the best line cross, but some good ones are now available. It is important to know more about the effect of the line cross on the final hybrid. This is discussed on pages 47 to 52. This project is not completed but is being continued.

The hybrid vigor obtained when sub-lines of the same inbred are crossed raised the question whether it might not be possible to make a satisfactory hybrid with two inbreds that in the beginning were somewhat closely related. To illustrate, Carmelcross is a satisfactory hybrid but there is considerable difference in the maturity of the two parental inbreds C13 and P39 so that in the crossing fields P39 must be planted two or three weeks before C13. The question naturally arose whether it might not be possible to take Carmelcross apart (by selfing), obtain two entirely new, although related, inbreds and put it back together by crossing the two new inbreds that mature at the same time. We believe that a cross similar to and as productive as Carmelcross may be secured by crossing two such inbreds, although they may have come originally from the same selfed ear. This runs counter to the popular teaching that related inbreds should not be crossed. If such can be done, the seed production problem can be greatly simplified by having two inbreds that flower at the same time. Inbreds in this project have now been selfed three times and will be crossed the first time in 1948. This is a continuing project and it is too soon to tell whether a good hybrid will emerge from it, but on the basis of the line cross results there are reasons to be hopeful of success.

Development of Good Inbreds by Selfing Hybrid Plants

Another project that has been under investigation since 1935 is one to determine the feasibility of securing good inbreds by selfing hybrid ears. At the time this program was started, plant breeders were considerably disturbed because some of the old open pollinated varieties were not being preserved.

Discussion regarding the best way of preserving open pollinated strains usually took place at every meeting of corn breeders. While such losses were inevitable, we do not think they were as important as they were represented. With all the hybrids available then and now, the possibilities for securing new inbreds by selfing hybrids could not be exhausted if maize breeders did nothing but self hybrids. We are as convinced of this today as we were in 1935 when we saved four hybrid ears for selfing the following year. These ears were all outcrosses so that only one of the parents of each line was known. Furthermore, the ears saved were open pollinated and could have been pollinated by any sweet corn in the immediate vicinity in the sweet corn nursery where they were growing.

Seed from these four ears was grown in 1936 and from 27 to 51 selfs were made from each one. In all, 161 S1 lines were grown in crossing plots in 1937. On the basis of growth made by those S1 inbred lines, they were reduced from 161 to 42, just 26 per cent of the total. On the basis of the performance of the hybrids grown in 1938, the inbred lines were reduced further to 23, or 14 per cent of the original lot, before inbreeding further. From those 23 lines that trace back to four original open pollinated ears have come

Figure 7. Purplecross C69 x 38. Inbred C69 produced by inbreeding hybrid ear.

three inbreds that are considered good enough to go into the numbered series and be put into commercial production. These three are C22, C68 and C69. Possibly one or two more will be added to the numbered series and produced commercially. Two of the above inbreds, C22 and C68, are as productive in themselves and have as good combining ability as any inbreds we have tested. These were derived from a program that started with only four ears. If such results are possible from selfing hybrid ears there is no cause for alarm over the loss of open pollinated stocks of corn. Three first class inbreds out of four original ears is not a bad percentage.

Products of this breeding program were the hybrids, Grant C22.27, Purplecross C38.69 and a new late variety, Pershing (C68 x Oh55). This last hybrid stood first in the Maryland trials the last two years and, in our trials in 1947, produced 153 per cent of the check (Goldengrain-Michael Leonard) in a 6 x 6 latin square trial. This difference was twice the amount required for significance with odds of 100 to 1. So these three hybrids, with possibly others yet to come, were produced during the course of the investigation of the possibilities of selfing hybrid ears. As pointed out previously, we believe this is the way hybrids should be developed by public institutions: as a product of their search for information of scientific value.

Future Breeding Projects

One of the research projects of the future will be a thorough investigation of sweet corn quality. Very little is in progress at present. It has been shown by Doty, Smith and others (Indiana Bulletin 503) (12) that certain inbreds are better in quality (in this case sugar content) than others when picked and that different inbreds lose their sugar at different rates. This should open up a whole new field of investigation. To breed intelligently for quality, we should know how rapidly the various inbreds lose their sugar content. Perhaps flavor is subject to similar differential change. We are confident that a comprehensive project on sweet corn quality investigations would not only supply us with much needed information but would also develop some sweet corn hybrids with quality superior to anything now grown.

MATURITY IN SWEET CORN

During the course of these investigations we have become increasingly conscious of the differences in maturity of sweet corn hybrids and the important part small differences in maturity play in the successful raising of sweet corn by the market gardener. Earliness is of prime importance. For extra early corn the price to the grower may be as high as $5.00 or $6.00 a hundred ears. Within a few days, perhaps two or three, this price may drop to $2.00 to $3.00 a hundred ears.

In denoting the earliness of any corn variety it has long been the custom to use the number of days from planting to maturity, saying a variety is a 60-day corn, a 75-day corn or perhaps a 100-day corn. One very early variety of flint corn, secured from Spain and used in developing Spanish Gold (Circular 75) (13), is called Cinquantino after the Spanish word for fiftieth, the day on which it is reputed to ripen. And it will just about do it, if planted at the time for optimum growth.

The date of planting has a great deal to do with the number of days required to reach maturity. If planted in March or April, a variety will require many more days to reach maturity than if it were planted about June

21 which seems to be the optimum date for planting if quick growth is desired. However, the corn planted in April will be more profitable than the late June planting because it will produce ears earlier in the season when the price is higher.

In 1935 several different hybrids were planted at approximately 10-day intervals from April 23 to July 10. The results regarding the time required to reach maturity from the different sowings were quite revealing. The results for two of the varieties, Spancross C2 and Redgreen, are shown in Figures 8 and 9. Spancross C2 required 88 days to reach maturity when planted on April 23 and but 62 days for the June 24 sowing. Therefore, is Spancross C2 a 62- or an 88-day corn? Likewise, Redgreen differed in days to maturity from 83 to 103. The 88-day Spancross would have been more profitable to grow than the 62-day corn since the latter would have come at a time when there was an abundance of corn.

Designating the maturity of a corn variety by the number of days is comparable to an automobile manufacturer designating different models or make by the maximum speed the autos are able to attain. Thus, we might have models varying in designation from 50 to 150 miles per hour. The

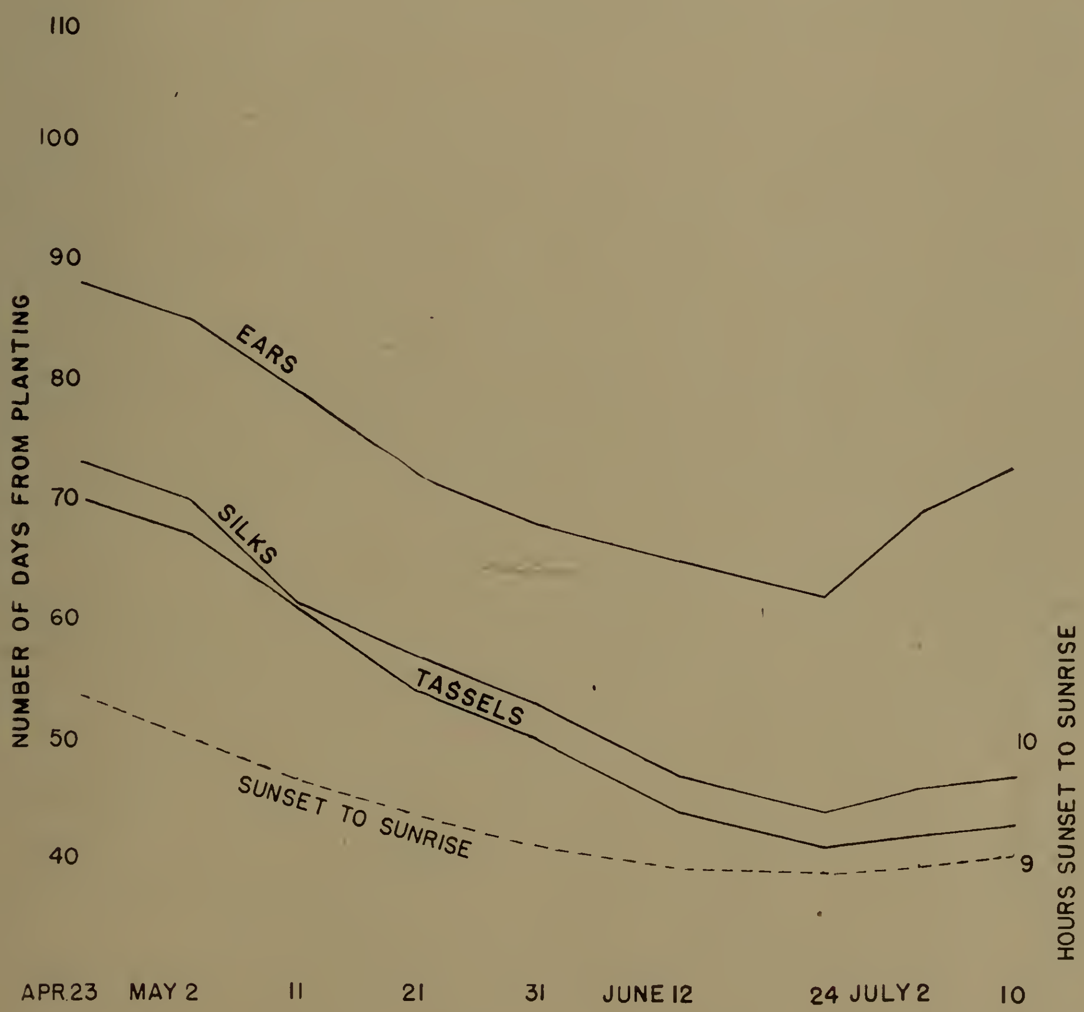


Figure 8. Graph showing number of days for the variety Spancross C2 from planting date to tassel, silk and ears for different planting dates from April 23 to July 10, 1935. As days become longer, variety requires less time from planting to ripening as is shown by lowest curve (dotted line).

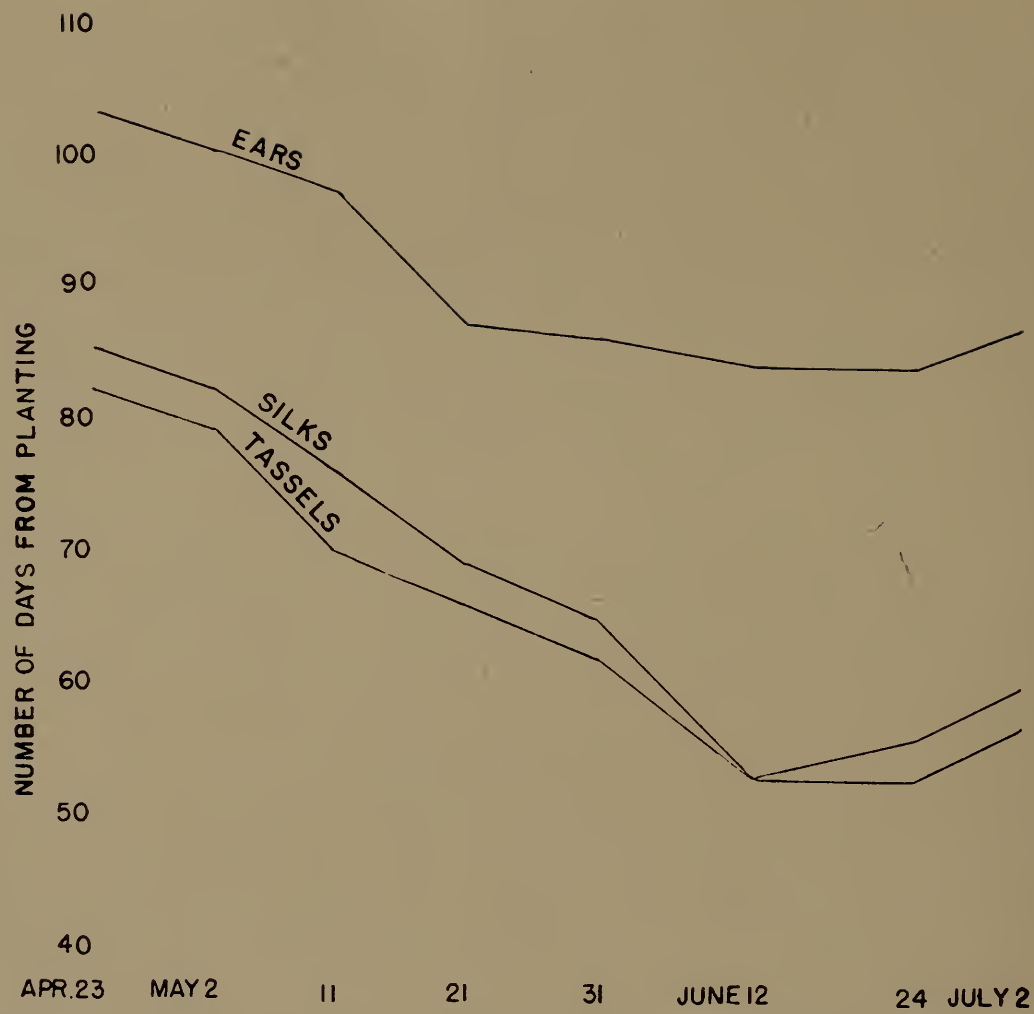


Figure 9. Graph showing number of days for the variety Redgreen from planting date to tassel, silk and ears for different planting dates from April 23 to July 10, 1935.

owner of a 150-mile car would undoubtedly find that the 150-mile speed was not the most economical speed of operation. Likewise, the corn grower has found it is more profitable to grow Spancross as an 88-day corn than as a 62-day corn because of the season in which the crop ripens. Use of days in designating maturity is of value only on a comparative basis. We prefer the use of names designating the seasons and, as a variety may become the established leader in that season, the use of the name of that variety for designating a season. The various seasons have been given the following varietal and seasonal names in our sweet corn breeding work:

Varietal and Seasonal Names for Designating Sweet Corn Maturity

Variety		Season	Appr. days after Spancross
Spancross	C13.3	Extra Early	0
Marcross	C13.6	Early	4
Carmelcross	P39.C13	Early Midseason	8
Grant	C22.27	Midseason A	12
Lee	P39.C27		
or		Midseason B	16
Lincoln	P39.C23		
Golden Cross Bantam	P39.51	Late Midseason	20
Wilson	C31 x 88		
or		Late	24
Pershing	C68 x Oh55		
Brookhaven	C53 x Oh55	Very Late	28

As varieties become better known, the use of their names rather than artificial seasonal ones serves as a superior method of designating seasons. If it is announced that a new variety is in the Golden Cross Bantam season, no one familiar with sweet corn would be confused as to the maturity of the new variety. Varieties differ so much in different locations that it is well to have several years trials in several places in comparison with the standards before stating categorically that a variety is in the Spancross or in the Marcross season. However, listing varieties by number of days is obsolete and serves no useful purpose.

NOMENCLATURE OF SWEET CORN HYBRIDS

"What is in a name? That which we call a rose, by any other name would smell as sweet . . ."

Or so Mr. Shakespeare tells us. It may be true for the smell of roses but it is not true for the taste of sweet corn. Retail seedsmen know that some names have more sales appeal than others. In some instances where one variety has been given two names, one has consistently outsold the other. Field corn hybrids have been accepted with numbers used for names. However, sweet corn growers prefer a name. Since this is true, a sweet corn breeder must have some system of naming his hybrids if they are to win popular approval of the growers.

Connecticut Station hybrids have been named by two systems. The first system used an abbreviation of the varietal name (from which at least one inbred was derived) plus the suffix "cross" in naming sweet corn hybrids. The use of the word "cross" was used to distinguish hybrids from open pollinated varieties (Circular 138) (3). Thus, Spancross indicated one inbred of this hybrid was derived from Spanish Gold. Marcross, C6.13, had one inbred (C13) out of Golden Early Market. At first we had two Marcross varieties, Marcross C13.6 and Marcross P39.C13. However, the trade refused to accept the numbers in addition to the names so Marcross P39.C13 was given the distinctive name Carmelcross. In this instance the "Carmel" was derived from the location of our experimental farm at Mt. Carmel. This naming system was used for only the three Connecticut early varieties, Spancross, Marcross and Carmelcross.

In 1941 a new naming system was proposed. Since hybrids were rapidly replacing open pollinated varieties, the need for names showing that varieties were hybrid no longer existed. It was assumed that all important varieties introduced would be hybrids and this assumption has proved to be warranted.

However, by 1941 many more hybrids were being introduced and these varied greatly in time to reach maturity. Consequently, it seemed advisable to have a system whereby a name would show automatically in what season a hybrid belongs. The system described in Circular 148(4) meets this specification. This system uses names from American history as varietal names; the earlier the name in American history, the earlier the variety. The varieties inaugurating this system were Lexington, Lincoln and Lee. Needless to say, Lexington was early while Lincoln and Lee were midseason varieties. These and other varieties that have been named according to this system are listed below. Unless otherwise noted, they are in commercial production. These mature in the order listed.

Figure 10. Patrick Henry C13 x 5, an early good quality market hybrid named by the system inaugurated in 1941.

Pocahontas[1]	C3 x 8
Plymouth[2]	C8 x G. Midget
Priscilla	C12 x 8
Patrick Henry[1]	C13.5
Lexington[3]	C13 x C15
Washington	C13 x 17-1 or C12 x 17-1
Jefferson[1]	C22 x 13
Walden[1] (after Walden Pond of Thoreau)	C17-1 x C35
Old Hickory (after Andrew Jackson)	C31.13
Grant	C22 x C27
Lincoln	P39.C23
Big Lincoln	C31.C23
Lee	P39.C27
Big Lee	C31.C27
Wilson	C31.87 original pedigree C31.88 present pedigree C31.Oh 55 possible future pedigree
Pershing[1]	C68.Oh 55
Hanford[1] (after nuclear energy plant)	C88.Oh55
Oak Ridge[1] (after nuclear energy plant)	C65 x Oh55
Brookhaven[2] (after nuclear energy laboratory)	C53 x Oh 55

It can be readily seen that this system can be expanded almost indefinitely. The names chosen are familiar ones. In most cases they are short and concise. Numbers need not be used in conjunction with the name, once the pedigree is known. This system has been accepted by the seed trade and growers alike, and seems to be working satisfactorily. Such names as Lincoln and Lee are familiar to almost every sweet corn grower.

[1] Not yet in commercial production.
[2] Being produced commercially for the first time in 1948.
[3] Discontinued.

Other sweet corn breeders use their own particular systems. Associated Seed Growers, New Haven, use Indian names for their new varieties, such as Erie, Sachem, etc. The Michael Leonard Company uses a combination of two words for describing their hybrids, such as Tendermost, Goldengrain, etc. The Robson Seed Farms use the word Seneca in most of their names for new sweet corn varieties. Other seedsmen and plant breeders in Experiment Stations select names as the need arises and may not have any definite system. William Lachman of Massachusetts University has named a new hybrid "Pilgrim". While this is an historical name it does not fit into our historical system since Pilgrim, Mass. 32.C27, is a midseason hybrid instead of a very early one which might have been expected had we used the name Pilgrim.

DESCRIPTION OF HYBRIDS

Hybrids Sold Commercially

Table 1 presents a list of the hybrids that have been developed by this experiment station and introduced between the years 1924 and 1948. The date of introduction is given for each hybrid, also the date discontinued if the hybrid is no longer in production. It also lists the seedsmen introducing the various hybrids.

Birthplace of Connecticut sweet corn hybrids. Corn plots at Connecticut Agricultural Experiment Station Experimental Farm with Sleeping Giant in background.

Table 1. Connecticut Experiment Station Sweet Corn Hybrids
1924—1948

Variety	♀ Parents[1]	♂	Year first seed sold	Year dropped	First sold by
Redgreen	75	77	1924	1942	A.
Crossgreen	Crosby	77	1927	1944	A.
Greencross	63	50	1930	1934	A.[2]
Whipcross P39	Whipple	P39	1934	1942	A.
Whipcross 6.2	6	2	1935	1942	A.,F.H.W.
Whipcross 7.2	7	2	1935	1942	C.F.,E.S.,K.C.L.
Whipcross P39.C2	P39	2	1935	1942	F.H.W.
Marcross C6	G.E.Mkt.	6	1935	1939	H.
Marcross P39	G.E.Mkt.	P39	1935	1939	E.S.,V.
Spancross C2	Sp.Gold	2	1935	1939	C.F.,E.S.,H.
Spancross 6	Sp.Gold	6	1935	1939	F.H.W.
Spancross P39	Sp.Gold	P39	1934	1939	A.
Pearlcross	E.Pearl	78	1937		H.
Marcross 3 way	Spancross 2	13	1937	1938	S.D.W.
Marcross 13.6	13	6	1937		E.S.,S.D.W.
Gemcross C6	Gem	6	1938	1940	E.S.
Golden Cross x C2	G.C.Bantam	2	1938	1942	E.S.
Carmelcross	P39	13	1937 as Marcross P39.C13 S.D.W.,E.S.		Cr.,K.C.L.,V.,H.,O.,S.D.W., F.H.W.
Spancross	13	4	1940	1947	Cr.,H.B.,K.C.L.,V.,C.F.,F.H.W.
Imp. Spancross	13	3	1946		A.,Cr.,K.C.L.,V.,F.H.W.
Lexington	13	15	1942	1944	Cr.,R.
Lincoln	P39	23	1942		C.F.,Cr.,H.B.,R.,K.C.L., S.,F.H.W.
Lee	P39	27	1942		Cr.,C.F.,V.
Patrick Henry	13	5	1943		C.F.
Old Hickory	31	13	1943		R.
Wilson	31	87	1943	1946	H.B.,R.,V.,N.K.,S.
Carmelcross	13	30	1943		Cr.,C.F.,V.,F.H.W.
Wilson	31	88	1946		Cr.,H.B.,R.,V.
Purplecross	69	38	1946		S.
Big Lee	31	27	1947		K.C.L.,R.
Big Lincoln	31	23	1947		R.
Big Goldencross	31	P51	1947		R.
Big Ioana	31	I45	1946		K.C.L.
Grant	22	27	1947 as 22.27 R., K.C.L.		H.B.,K.C.L.
Priscilla	13	8	1948		R.,F.H.W.
Washington	13	17-1	1947		R.
Washington	13	17-2	1948		C.F.

1 All inbreds Connecticut lines unless otherwise indicated.
2 Produced and distributed in a limited way as samples. Not sold commercially.
P = Purdue inbred.
I = Iowa.

A.	Associated Seed Growers	New Haven, Conn.
C.F.	Comstock Ferre & Co.	Wethersfield, Conn.
Cr.	Crookham Company	Caldwell, Idaho
E.S.	Eastern States Farmers' Exchange	W. Springfield, Mass.
H.	C. C. Hart Seed Co.	Wethersfield, Conn.
H.B.	Huntington Brothers	Windsor, Conn.
L.	D. Landreth Seed Co.	Bristol, Pa.
K.C.L.	K. C. Livermore	Honeoye Falls, N. Y.
N.K.	Northrup King Co.	Minneapolis 13, Minn.
O.	Edgar L. Oakes Seed Co.	Caldwell, Idaho
R.	Maurice Rogers	Orange, Conn.
S.	Max Schling Seedsman	New York, N. Y.
V.	Vaughans Seed Co.	Chicago, Ill.
F.H.W.	F. H. Woodruff & Sons	Milford, Conn.
S.D.W.	S. D. Woodruff & Sons	Orange, Conn.

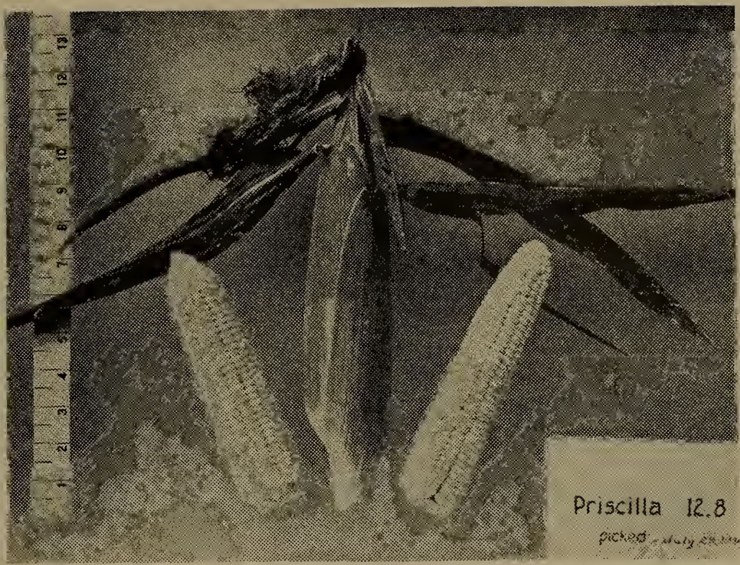


Figure 11. Priscilla C12 x 8, an early hybrid of good quality for the home or market gardener.

Transition from Open Pollinated Varieties to Single Crosses

The first three hybrids in Table 1 were described in Bulletin 361(1). Redgreen was produced in a limited way from 1924 to 1942 while the Crossgreen hybrid was produced commercially from 1927-1944. The hybrid Greencross was never sold commercially but a few samples were distributed, presumably in 1930. Under ideal conditions this hybrid produced an unusually large ear but had a weak root system which made commercial production inadvisable. Perhaps the greatest usefulness of these three hybrids was the demonstration of the remarkable uniformity and also productivity of hybrid corn made by the pure line method.

Whipcrosses 6-2, 7.2 and P39 were also described in Bulletin 361(1). The first two were single crosses that matured in the Whipple season. They were more uniform and productive than the open pollinated variety, also more resistant to bacterial wilt. The quality was only fair, similar to Whipple. They were discontinued when Lincoln and Lee were introduced in 1942. Whipcross P39 was a top cross (the hybrid between an open pollinated variety and an inbred) and as such was more variable than the single crosses. It was productive, had better quality than Whipcross 6-2 or 7.2 and was resistant to bacterial wilt. It served a useful purpose as a temporary hybrid while single crosses were being developed. In fact, or so it seems to us, that is the only purpose of top crosses in a breeding program since they lack the uniformity so essential to sweet corn growers. Whipcross P39 was discontinued as soon as Lincoln and Lee were developed.

Whipcross P39.C2 was a productive midseason single cross but did not have as good quality as Lincoln and Lee. Consequently, with the introduction of those two varieties the need for 39.2 ceased to exist. Marcross C6 and P39 were two top crosses that were grown a few years before the introduction of Marcross and Carmelcross. Marcross C6 was in the Marcross 13.6 season and Marcross P39 matured at about the same time as Carmelcross. These two top crosses had the usual merits and disadvantages of top crosses. The same could be said of the next three top crosses in Table 1. Spancross C2 and Spancross C6 were replaced by Marcross C13.6 while Spancross P39

was replaced by Carmelcross. The Marcross three way cross was a hybrid of Spancross 2 x C13. It was extremely variable and was produced commercially only one year.

Gemcross C6 was an early top cross that was replaced by Spancross C13.4. Golden Cross 2 was a three way hybrid made with Golden Cross Bantam as the seed parent and Connecticut 2 as the pollinator. It was discontinued upon the introduction of Lincoln and Lee.

The foregoing hybrids might well come under some such heading as "The transitional phase from open pollinated to hybrid varieties". They served a place in giving the grower something better than the original open pollinated varieties but were not as good as uniform single crosses. They also served the function, as pointed out previously, of creating an interest in hybrid sweet corn.

Pearlcross is a top cross white hybrid maturing in midseason. It has an ear too small for the general market but one that is very sweet and tender,

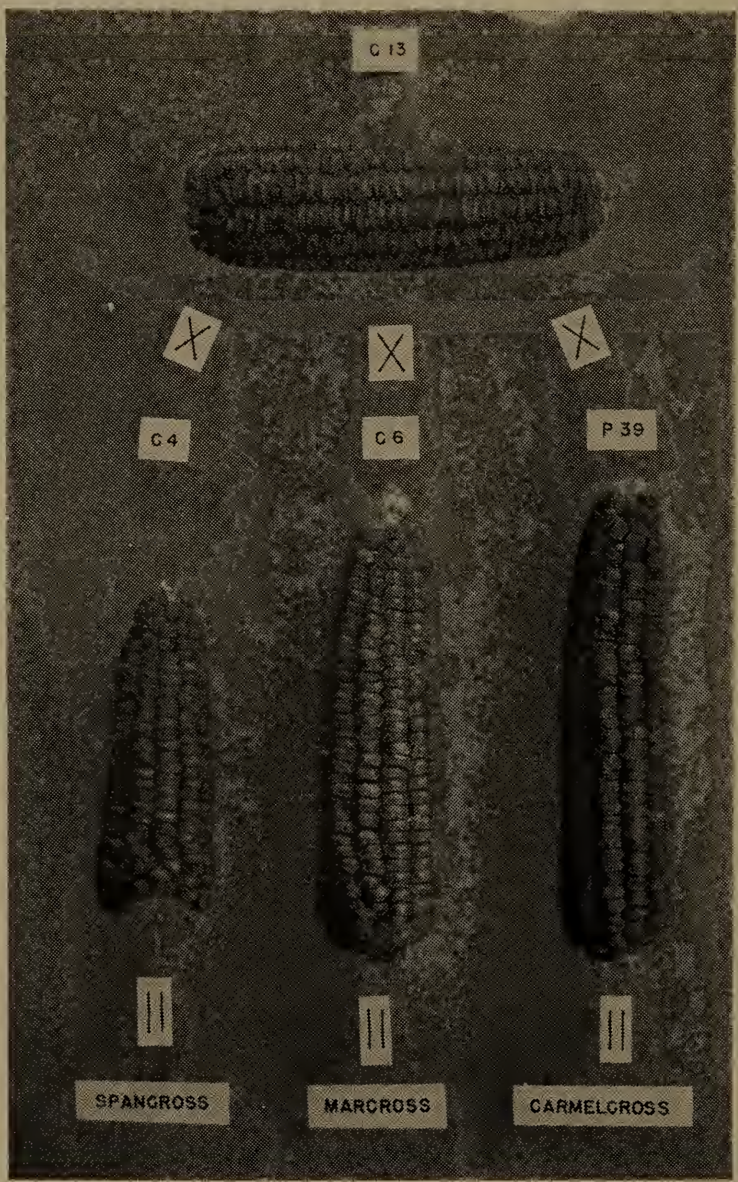


Figure 12. Inbred parents of Spancross C13.4, Marcross C13.6 and Carmelcross P39.C13.

and is suitable for home gardeners or for those selling at a roadside stand. Since it is a white hybrid, it may never become as popular as a comparable yellow hybrid. Two such experimental hybrids, 35 x 42 and C35 x 81, are available and could be produced commercially. C35 is a line secured from a Yellow Early Pearl and C81 is the yellow counterpart of C78. C42 is an early backcrossed P51 line. These inbreds are described on pages 31 to 39.

Early Productive Single Cross Hybrids

The three early hybrids, Spancross, Marcross and Carmelcross, set new standards of performance for their various seasons. These three varieties are still being grown in considerable quantity, although in the case of Spancross one inbred in the pedigree has been changed. C3 is now used instead of C4 as the Spanish Gold component of the hybrid Spancross which now has the pedigree C13 x C3. The new hybrid is at present as early as any commercial hybrid and is useful for those growers who have a light soil that can be planted early. It is fairly cold hardy and can be planted successfully as soon as the soil can be worked in the spring. It produces a seven-inch ear weighing about .6 of a pound with the husks on and about .38 to .40 pound husked. The stalk is short, not over four to five feet tall. The ear is almost cylindrical with considerably less taper than the old Spancross 13.4. The quality is also better than 13.4. It is resistant to bacterial wilt.

Marcross (C13.6) produces an unusually large ear for such an early corn. The ears average about .75 pound with husks on and about .50 pound husked. Such ears are about eight inches long after the husks are removed. The plants of Marcross usually are five to six feet tall in the latitude of southern Connecticut. Marcross is resistant to bacterial wilt, *Bacterium stewarti* (E.F.S. Stev.), but somewhat susceptible to smut, *Ustilago Zeae* (Beckm.)Ung. In some years in Burlington County, New Jersey, losses have been heavy because of smut. The quality of Marcross, freshly picked, is usually considered good. In judging the quality of any of the early varieties, it must be borne in mind that no high quality varieties are available for comparison in the general market. Hence, one classified as good, early in the season might be poor, or at least mediocre, if compared with such varieties as Golden Cross Bantam. Marcross is not well suited to canning or freezing, although it is being used for this purpose in areas with a short growing season.

Carmelcross (P39 x C13), the latest of the three hybrids described in Circular 138, matures about four days after Marcross. It has more vegetative vigor than Marcross and has a medium green wavy leaf characteristic of P39, one of its parents. The average weight of the unhusked ears is about like Marcross, from .70 to .75 of a pound, but the ear is a little more slender and has more rows of kernels and, consequently, a narrower kernel. The husked ears will commonly weigh .5 of a pound each and are about eight inches long. The plants are 5½ to 6½ feet tall in Connecticut. The hybrid is resistant to bacterial wilt and smut and is partially replacing Marcross in areas where smut is an important disease.

Most of the Carmelcross produced is now made with the inbred C30 as one parent instead of P39. C30 is a mutation from P39 and was formerly known as P39-10 when discovered by the Crookham Company in Caldwell, Idaho. The inbred will be described in another section of this bulletin. Carmelcross C13.30 gives as good or better results than Carmelcross P39.C13. When P39 is used as one parent, much depends upon which strain of P39

is used, since it is known that there are many strains of this inbred. There are fewer strains of C30 and, since it is a monogenic recessive, any outcrosses are immediately detected. Consequently, we believe it advisable to make Carmelcross with C30 rather than P39. The hybrid 13 x 30 seems to us a little more uniform than 39 x 13. However, both hybrids are good and a grower must determine on his own farm which he prefers.

Lexington, Lincoln and Lee, Early and Midseason Hybrids

The three varieties Lexington, Lincoln and Lee were described in Circular 148(4) in 1941. Since copies of that circular are still available, these varieties will be described only briefly here. Lexington C13 x 15 is an early hybrid maturing in the same season as Marcross. The plant is five to six feet tall. erect and uniform. The ears are somewhat more slender than those of Marcross, but with a rather tight husk, giving them a little more attractive appearance. The slightly tapering ear usually has 12 to 14 rows of rather narrow kernels. The plants of Lexington are quite similar to. but slightly taller than those of Marcross. This variety is no longer grown because of its similarity to Marcross.

Lincoln, C23 x P39. is a single cross designed primarily to replace the old top cross Whipcross P39. It is a midseason hybrid maturing two or three days before Golden Cross Bantam. The ear is rather large and cylindrical and has 12 to 16 rows of narrow kernels. The kernels have a lustre that gives Lincoln considerable "eye-appeal", an important sales advantage. The ear is borne rather high on an erect stalk that is resistant to lodging. The plants are seven to eight feet tall. The quality of Lincoln is very good, although not as good as Golden Cross Bantam. Both crosses have one parent in common, Purdue 39.

Lee. P39 x C27, is also a midseason hybrid. It has an ear slightly larger than that of Lincoln, with 12 to 14 rows of rather broad kernels. The ear is slightly tapering and somewhat barrel-shaped. The quality is very good to excellent, being a little better than Lincoln. It matures in the same season as Lincoln, about two or three days before Golden Cross. Trials in Connecticut and elsewhere indicate that under favorable growing conditions Lee will give a bigger ear than Lincoln but that Lincoln does better over a wide range of conditions. Hence, Lee is recommended for the New England States, whereas Lincoln can probably be taken farther south and west.

Patrick Henry, Old Hickory and Wilson Sweet Corn Hybrids

Patrick Henry C13.5 is an early yellow market sweet corn maturing in southern Connecticut about a day before Marcross. The plant of Patrick Henry is short and sturdy, with few tillers. Ordinarily it does not attain a height of more than five feet and may be as short as four feet. The ear is similar in shape to Marcross although a little shorter. averaging about seven inches. The quality of Patrick Henry is good to excellent, being considerably better than Marcross. It is not in commercial production because of the difficulty of growing the inbred C5. These difficulties are being overcome and Patrick Henry will be produced soon. Its short height may make it a good variety for dusting by machinery to control the European corn borer.

Old Hickory C31.13 (named for Andrew Jackson) is essentially a large-eared Carmelcross. The plant is similar except that Old Hickory is slightly taller and more rugged. It is usually a day or two later than Carmelcross

although in some localities there is little difference. In some areas it makes a considerably better growth than Carmelcross. This is usually the case when moved to regions south of Connecticut. As in the case of Patrick Henry, production difficulties need to be overcome before this hybrid is available generally.

There are several strains of the C31 inbred and it has not been decided which is the best to use for making Old Hickory. Also, the inbred C31 is so much bigger than C13 that it is difficult to use 31 as a seed parent and secure proper pollination. Perhaps it will be necessary to make the hybrid with C13 as the seed parent, as is done with the Carmelcross C13.30. Also, it may be possible to make Old Hickory with a genetic short line of C31. Such a short line is now available and being tested. If Old Hickory is a hybrid of sufficient merit, production difficulties will be overcome.

Wilson C31.C88 (named for Woodrow Wilson) is a big-eared, late, yellow corn maturing about a week after Golden Cross Bantam. Where properly grown, the stalk is erect and sturdy with dark green leaves. The root system is good and there is little lodging. At Mt. Carmel, Wilson usually grows 8½ to 9 feet tall in comparison with seven feet for Golden Cross Bantam. In ear size Wilson exceeds Golden Cross, measuring nine inches long by two inches

Figure 13. Brookhaven C53 x Oh55, showing vigorous plant growth, a little better than the new Wilson C31 x Oh55.

in diameter in comparison with eight inches, and 1½ inches for Golden Cross. The husked ears of Wilson average about .7 pound while those of Golden Cross weigh between .45 and .50 pound.

The Wilson originally introduced had a slightly different pedigree, C31.87. However, the inbreds 87 and 88, both yellow Stowells inbreds, are closely related and give hybrids similar in appearance. The C88 line has more smut resistance and is being used instead of C87. Also, the inbred C88 has entirely green silks, anthers and glumes so the new Wilson is completely green like Golden Cross Bantam. Under ideal conditions Wilson produces a good yield of high quality corn suitable for the market garden or for canning. However, under somewhat less than ideal conditions, Wilson is not a reliable performer in that it produces very few good ears or ears poorly filled on one side. Another similar hybrid, C31 x Oh55, is a better all around performer and may be substituted for Wilson in the near future, keeping the same name of Wilson. It is hoped that the third pedigree will be the most successful.

Newer Hybrids Coming into Production

Purplecross C69.38 is a hybrid having fully purple leaves and stalks. It matures a few days after Golden Cross Bantam and is more productive. Quality is not as good as Golden Cross, but considered fair to good. Since the plant is fully purple, the cob has deep purple color and some of the color comes out in the water when the corn is cooked. To some, this is a serious objection. Purplecross has done well in some sections of the south and should perhaps be tried more extensively. The C69 parent is a dilute purple *AbPl* while the C38 is a sun red *ABpl* strain of P39. The hybrid is fully purple because of the dominant complementary action of the *B* and *Pl* genes, in this case brought in by different parents.

The next four hybrids in Table 1, Big Lincoln, Big Lee, Big Golden Cross and Big Ioana are made by substituting C31 for P39 in making the hybrids. The "big" hybrids are a little more rugged with a somewhat more luxuriant foliage growth and somewhat larger ears. Where the regular hybrids do well it is probably not advisable to substitute the big hybrids. In areas of somewhat more adverse growing conditions it might be well to try samples of the big hybrids to test their performance. The quality of these hybrids is probably not as good as the regular hybrids. Further tests are necessary on this point.

Grant C22.27 is a productive large-eared hybrid with rather good quality, maturing just after Carmelcross and before Lee. The need has long existed for a productive market hybrid in the old Whipcross 6.2 or open pollinated Whipple season. Grant apparently meets this need although it needs further testing under different environmental conditions. The plants of Grant are about six feet tall and rather vigorous with several tillers. The ears are large, measuring 8½ inches long by two inches in diameter and averaging .6 pound husked and about .85 with husks on. Grant has considerable drouth tolerance but is only moderately resistant to bacterial wilt, similar in this characteristic to Lee with which it has one parent, C27, in common.

Priscilla, C13 x 8, is an early hybrid maturing in the Marcross season or a little before Marcross. The pedigree of this hybrid will probably be C12 x 8 as soon as the inbred C12 is produced commercially. One feature of Priscilla is its ability to make a good start even in a cold soil. This charac-

teristic comes largely from the C8 parent. The stalk of Priscilla is vigorous and thrifty showing considerable similarity to Marcross. The ears are somewhat smaller than Marcross with a slightly lower row count. The quality has been found by some to be better than Marcross but more tests are needed on this point as well as on its general performance.

Washington, C13.17-1 or C13.17-2, was designed as a market garden corn in the Marcross season but with better quality than Marcross. The 17 lines are backcrossed P39 lines and have better quality than C6, one of the parents of Marcross. The ears of Washington are similar in size and shape to Marcross and the plants show considerable similarity. Since Washington is a new variety, more tests of all kinds are needed to determine its performance and adaptation. Whether it will replace Marcross is not possible to state at this time. It may be one of several new hybrids of better quality that will eventually replace Marcross.

Figure 14. Washington C13 x 17, an early hybrid in Marcross season but with better quality.

Experimental Hybrids Worthy of Extensive Testing

Before closing this section on sweet corn hybrids, perhaps a few brief comments are in order regarding experimental hybrids that have shown considerable promise in one or more years of trial. Some of these will undoubtedly be produced commercially in the future. In fact, at least two, Brookhaven C53 x Oh55 and Plymouth (Golden Midget x C8), are being grown in a limited way in 1948 with others to follow in 1949. Table 2 presents a brief description of the best of the experimental hybrids.

TABLE 2. EXPERIMENTAL HYBRIDS WORTHY OF COMMERCIAL PRODUCTION

1947 Trials planted May 15. Rows 21 feet long.

Pedigree	Suggested name	Date ½ silks July	Total plants	Date picked	Wt.	Mkbl. ears	10 best ears Diam.	10 best ears Lgth. inches	10 best ears Wt. lbs.	Number of kernel rows: Ears in each class 8	10	12-14	16+	Quality
C3 x 8	Pocahontas	11	21	7/28	8.6	20	15	7.2	3.0	4	11	6		
2.3 x 8	Pocahontas	12	22	28	12.0	19	17	7.4	3.6	5	2	12		
C2.3 x 12	Spancross[1]	12	25	28	15.9	25	19	7.0	4.7	3	3	18	1	
3 x 12	Spancross	11	16	28	9.6	12	18	6.9	4.0	1	1	10		
Check	Spancross 13.3H	11	24	28	13.5	19	17	7.0	3.9	4	2	12	1	
G.Midget x 8	Plymouth[1]	15	21	31	7.5	31	11	6.2	1.5	28	3			
G.Midget x S2	Harvard Hybrid	15	23	31	5.7	22	12	6.7	1.6	22	0			
C8 x Dorinny		14	21	31	8.0	24	13	7.0	2.2	24	0			
CB13 x 8	Priscilla[1]	16	22	31	12.3	19	15	7.5	3.4	1	2	16		
13 x 6 check	Marcross	17	20	8/4	13.0	17	17	7.6	4.5	1	2	14		
C9 x 12[1]		14	26	4	16.0	20	18	7.9	5.1	1	2	17		
C9 x 13[1]		14	26	4	17.0	22	18	7.3	4.6	2		20		
CA13 x 17-1	Washington	14	26	4	17.4	24	17	7.6	4.5	0	0	24		
CB13 x C11[1]		17	29	4	16.6	24	16	7.6	4.0	0	0	24		
17 x C11[1]		16	22	4	15.0	24	16	7.3	4.0	1	4	19		
22 x 13	Jefferson	20	19	9	14.5	18	19	7.9	5.7	0	0	15	3	
13.30 check	Carmelcross	19	26	7	16.1	24	18	7.8	5.0	1	0	19	1	
17-3 x 40	Early Golden Cross	21	21	9	13.5	19	15	8.7	4.1	0	0	19		4:4[2]
35 x 17-1	Walden[1]	18	20	7	12.0	21	17	7.7	3.8	0	0	21		
C. Blue x 36[1]		19	24	7	10.2	21	14	7.6	3.0	5	14	2		5:5
22 x 42		24	22	12	14.2	20	17	8.2	4.8	1	2	17		
938-22 x 22		21	22	11	12.7	17	18	7.6	4.7	0	0	13	4	2:3
35 x 40[1]		21	26	11	12.7	23	16	7.8	4.0	0	2	21		3:4
C18 x 40		21			v.g.	plant and ear				0	2	25		
27 x 41-12[1]		22	23	14	20.3	26	19	8.4	6.0	0	1	25		3:4

Pedigree	Suggested name	Date ½ silks July	Total plants	Date picked	Wt.	Mkbl. ears	10 best ears Diam.	10 best ears Lgth. inches	10 best ears Wt. lbs.	Number of kernel rows: 8 (Ears in each class)	10	12-14	16+	Quality
27 x 39M92	Lee	26	26	14	18.4	25	19	8.6	5.7	0	0	13	12	3:3
35 x 81	Rutledge[1]	24	18	14	10.3	19	16	7.4	4.1	0	1	18		4:4
23 x 39M92	Lincoln	26	24	14	18.6	21	19	8.8	5.9	0	0	1	20	2:2
68 x 39M92	Golden Spike[1]	30	25	19	14.0	23	16	7.6	4.2	0	0	18	5	4:2
P39.51 Cr GCB	(for comparison)	29	22	15	9.1	14	15	8.0	3.9	0	1	13		
C68 x Oh55[3]	Pershing[1]	31	23	8/19	21.8	25	18	8.9	5.7	0	0	7	18	2:2
53 x Oh55	Brookhaven[1]	6	24	9/3	24.0	23	22	9.6	9.1	(little old)		17	6	1:2
65 x Oh55	Oak Ridge[1]	8	25	3	27.6	24	21	9.0	8.1	0	0	0	24	
Oh55.C88	Hanford[1]				Average		19	8.9	6.4	in Latin Square Yield Trial				
31 x Oh55	Wilson[1]				Average		17	8.8	5.0	in Latin Square Yield Trial				
C31.88	Wilson	8/2	24	22	12.3	17	19	8.8	5.9	0	0	8	9	

1 Most outstanding hybrids.

2 First number refers to tenderness of pericarp, 2nd number to flavor. Both are graded on a scale of 1-5, 1 being poor and 5 excellent.

3 Oh55 inbred developed by Dr. J. B. Park, Ohio State University, Columbus, Ohio. This is an unreleased line but permission has been granted to use it in making of commercial sweet corn hybrids under our supervision.

TESTS AND DESCRIPTIVE DATA USED IN EVALUATING HYBRIDS

Both the commercial and experimental hybrids have been subjected to various tests before being judged worthy of more extensive trial or commercial use. Testing at best is a difficult problem and probably no two plant breeders use exactly the same methods. Each one has to work out a test which seems to give the most information for the amount of time and effort involved.

At the Connecticut Station we have been somewhat limited in land for testing. Consequently, we have been forced to limit our testing program to our own experimental hybrids in addition to a few standard hybrids to serve as "checks" or standards of comparison. Since it is possible to make such a large number of hybrids of various combinations with comparatively few inbred parents, there are usually more hybrids than can possibly be tested adequately by any of the well known statistical designs. Consequently, the following types of tests have evolved:

1. *Observation trials.* Hybrids are tested the first time in this trial. Rows are approximately 25 feet long and contain approximately 25 plants spaced a foot apart. Almost perfect stands are secured by planting thick and thinning to one plant per place. This trial, consisting of 250 to 500 hybrids is grown on as uniform soil as possible. With the large number that require testing and with limited land, it is not possible to replicate the varieties.

Notes on the type of plant growth, including early seedling vigor and date of silking, are made throughout the growing season. In the fall the ears are husked and a description of the ears taken. Notes are also made on which hybrids are to be grown again. Usually about 50 to 75 per cent of the hybrids are discarded on the basis of one trial of only one row each. We realize that some good hybrids are discarded. We also expect that some or perhaps most of the good hybrids are saved for further testing. The fact that this system has produced a considerable number of good hybrids is an argument for its continued use.

2. *Quality tests.* Hybrids that have done well in the observation trials are then grown in the "quality test", although it is advisable to grow these hybrids in a second observation trial as well.

The quality test, in which the ears are harvested when green, furnishes much more information than the observation trial. We can then tell what type of ear the hybrid is capable of producing at the edible stage. Also, more information is obtained on the uniformity of hybrids tested. Only one picking of each entry is made, picking date being determined roughly by the date when the plants silked. If a hybrid shows much variability, it will be immediately detected by the range in maturity of ears picked only once. When we first began picking sweet corn in the green stage we discarded immediately the old top cross, Spancross C2, because of its extreme variability at this stage. In the previous trial the ears harvested in the fall gave no indication of this variability.

Another character that can best be judged in the green state is the amount of taper. Ears that are extremely tapering when green may not appear so when the dry ears are observed, possibly because of a greater relative growth near the tip of the ear after the edible stage. These tests also give an indication of quality. The corn is either chewed raw or two or more samples are cooked for comparison. Both tests have been useful in detecting

Figure 15. Brookhaven C53 x Oh55, one of largest, latest and most productive hybrids developed at the Connecticut Station.

large differences in quality, but objective quality tests for measuring small differences are an important need in a sweet corn breeding program.

Usually in the quality test the varieties are not replicated, but they are not discarded as heavily as in the observation trials. Perhaps 50 to 75 per cent of the entries are grown again in the quality test and the best are put in more exact yield trials. The type of data obtained on the quality tests is shown by the following table headings used in our field notebooks:

	Total	Date		No. Mkbl.	10 Best Ears			Row number				
1/2 S	Plants	Picked	Wt.	Ears	Dia.	L.	Wt.	8	10	12-14	16+	Quality

Each entry has a page in the field notebook. The data filled in under the various table headings are intended to give a description of the hybrid rather than giving much information on yield, although the number and weight of ears is an indication of yielding potential.

The 10 best ears (or the top half of a sample of 20 to 25) is not intended to give an average but rather an idea of the best that a hybrid can do. It is not possible, without careful and accurate measurements, to pick 10 ears out of a sample of 20 and have the sample be the exact average. Consequently, we use the best 10, knowing we have a selected sample, but one which should be comparable for all varieties in the test. It would tend to favor variable hybrids and discriminate against very uniform ones. However, in single crosses, differences in uniformity are slight and any hybrid showing too much variability will be discarded anyway.

In scoring the hybrids for number of rows we use three classes, 8 rows, 10 to 14, and 16 or more. This is done because of ease in classification and also because the three headings define rather well different types of ears. The eight-rowed ears are distinct from all other corn and are easily spotted. Ears having 16 or more rows can usually be identified without counting the rows, although it is sometimes necessary to count the rows to verify the first judgment. Ears not judged as either in the eight-row class or the sixteen or more are automatically put in the 10-14 row class or "down the middle" in the parlance of the helpers who do the scoring of sweet corn.

The method of making tests and taking notes is described in considerable detail so that the reader may be more familiar with the methods and consequently be in a better position to judge results obtained by these methods. They are not advocated as the ideal method for anyone else to follow but might well serve as a point of departure for anyone setting up a breeding program. Everyone has to work out his own system and any success achieved will be dependent upon some system. Plant breeding in general, and sweet corn breeding in particular, is composed of half system and half sweat and neither component can be substituted for the other. We are not sure the proportions stated are correct but feel rather sure of the ingredients.

3. *Windsor Observation Trials.* Each year approximately 100 of the supposedly best hybrids in the observation trials are grown on the grounds of the Tobacco Laboratory at Windsor on a different soil type, a fine sandy loam. These trials are handled very much the same as the observation trials at Mt. Carmel, except that the ears are harvested green. The number and weight of ears (with the husks on) are recorded. Considerable information of value is obtained in these trials. Growing conditions are fairly similar to those of commercial growers.

4. *Yield Trials.* When it is desired to ascertain small differences in yielding ability an exact statistical design is used. If the number of varieties is small the latin square is the best design to use on a soil of considerable variability. It is usually possible to keep the number of varieties small since those being tested can be divided among several different maturity seasons. A 6 by 6 latin square has been used more than any other. With this design six varieties are replicated six times in randomized rows and columns in such a way that every variety appears once in every row and column. With this design it is possible to determine soil variability in each direction and subtract this from the total variation, thus giving the amount that can be attributed to varieties and to error. The relationship of these last two figures determines how much of a difference is required for significance. Descriptions and uses of the latin square can be found in Snedecor's Statistical Methods. As stated previously, this test is useful in detecting small differences in any one year. Tests must be repeated in other years and in other locations to determine the adaptability of a given hybrid.

A representative 6 x 6 latin square is presented below. This presents yields of very late sweet corn hybrids in 1947.

Table 3. Latin Square 4. Very Late Sweet Corn Hybrids. 1947

Variety	Total wt. ears lbs.	No. ears	Av. wt. lbs.	Average diameter in.	Average length in.
Brookhaven C53.Oh55	210	214	.69	1.97	8.72
Pershing C68.Oh55	198	226	.57	1.87	8.73
C69 x Oh55	181	228	.53	1.82	8.11
Wilson C31-1.Oh55	178	232	.50	1.71	8.83
Hanford C88.Oh55	173	184	.64	1.89	8.94
Goldengrain Michael Leonard	130	171	.55	1.95	7.54
L.S.D. .01 level	34	43	.34	.37	.9

Figure 16. Persining variety, C68 x Oh55, productive late hybrid.

DESCRIPTION OF INBREDS

Table 4 gives a list of all the Connecticut sweet corn inbreds that have been used commercially during the period 1924-1948. These inbreds all have the capital letter C (for Connecticut) as a prefix. In general the numbers from one to one hundred have been reserved for sweet corn inbreds released for use in seed production. As a rule the lower the number within this series, the earlier maturing the inbred. A few exceptions should be noted, mostly inbreds that were released before this system was begun. C6 is later than it should be for this series. If it were numbered 16 it would more nearly conform to this system. The 31 line is also later than it should be and would better fit in the 40 series. Likewise, the inbreds 53 and 65 are about in the 80 series as far as maturity is concerned. However, these inbreds have been distributed to a limited extent under the present numbers and there would be considerable confusion if the numbers were changed. C2A and 3 are the earliest lines developed and C95 is the latest. In general the inbreds are correctly numbered according to maturity.

Figure 17. Connecticut 13 early sweet corn inbred, used as seed parent in practically all early market sweet corn hybrids.

TABLE 4. CONNECTICUT SWEET CORN INBREDS

1924-1948

Inbred	Source of germ plasm	No. inbred lines started	Year inbreeding began	Generation inbred when first crossed	Approx. plant height 1947 inches	Color of silks	Color of glumes	Color of anthers	Number of kernel rows
C2	Whipple, Silas Whipple	17	1924	3	discontinued				
C2A	Spanish Gold	238	1932	3	39	pink	red	red	8-12
C3	Spanish Gold	238	1932	3	36	pink	red	red	8-10
C4	Spanish Gold	238	1932	3	40	green	red	red	10-14
C5	Spancross[1] P39	59	1935	1	35	green	green	green	12-18
C6	Whipple, Harris	90	1924	3	60	pink	red	reddish	12-14
C7	Whipple, Harris	90	1924	3	discontinued				
C8	E.E.G. Bantam, Gaines	8	1941	3	38	green	red	red	8
C9	Market Gem, Crookham	100	1941	3	48	red	red	red	8
C11	Market Gem, Crookham	100	1941	3	52	green	red	red	8-12
C12	Me.Bantam.C13[1]	2	1941	1	48	pink	red	red	10-14
C13	Golden E. Market	18	1931	3	44	pink	red	red	10-14
C15	Black Mex. x Sp. Gold	10	1933	3	58	green	green	green	10-14
C17-1	ESD43.13[2] x 39	5	1941	1	49	pink	red	red	10-12
C17-2	ESD43.13[2] x 39	5	1941	1	46	green	green	green	12-18
C18	(Cream-o-Gold) 857-67x36	5	1942	2	62	red	red	red	12-14
C22	Tendergold 24 outcross	27	1936	1	60	green	green	green	12-18
C23	Whipple, C. Ferre	48	1935	1 - 3	77	green	red	red	12-14
C27	Whipple, C. Ferre	48	1935	1 - 3	65	deep red	red	red	12-14
C30	P39 mutation Crookham	?			35	green	green	green	10-16
P39 (Conn. strain)					58	green	green	green	12-16
C31-1	LIBeauty.P39[3]	6	1937	1	72	green	green	green	16-20
C31-2	LIBeauty.P39[3]	6	1937	1	72	green	green	green	14-16
C35	E.Pearl[2] x Ysu	10	1938	2	53	red	red	red	10-14
C36	E.Pearl[2] x Ysu	10	1938	2	46	red	red	red	8-12

Inbred	Source of germ plasm	No. inbred lines started	Year inbreed-ing began	Generation inbred when first crossed	Approx. plant height 1947 inches	Color of silks	Color of glumes	Color of anthers	Number of kernel rows
C37	(P39.L.Hill) C30xP39	3	1942	3	67	green	green	green	12-16
C38	85.39^{4}	5	1940	3	60	pink	red	green	12-16
C40	957-3 x P51^{2}	5	1940	2	65	green	green	green	8-12
C41	C75 x P51^{2}	5	1937	3	65	pink	red	red	8-10
C42	C75 x P51^{2}	5	1937	3	56	green	green	green	8
P51 (Conn. strain)					60	green	green	green	8
C50 White	Stowells Evergreen	199	1921	4	discontinued				
C53 Yellow	Ysu.C50^{3}	5	1937	3	74	pink	red	red	12-16
C63 White	Stowells Evergreen	199	1921	4	discontinued				
C65 Yellow	Ysu.C50^{3}	5	1938	3	85	pink	red	red	16-20
C68 Yellow	C7 outcross	42	1936	1	82	pink	red	red	12-16
C69 Yellow	Tendergold 24 outcross	27	1936	1	77	deep red	red	purple	16-20
C78 White	G.Giant x 75^{3}	5	1928	3					
C81 Yellow	75^{2}.51	5	1937	3	66	pink	red	red	8-14
C88 Yellow	658 x 77^{3}	5	1937	3	80	green	green	green	12-18
C95 Yellow	39.85 x L.I.Beauty^{1}	10	1937	3	99	green	green	green	16-24

Superscript 1 means backcrossed once to the inbred having the superscript number.
Superscript 2 means backcrossed twice, etc.

Figure 18. Purdue 39, most widely used sweet corn inbred.

Rather extensive data on maturity are found in Figures 19 to 22. These data were all secured in 1945 from four different plantings of 24 inbreds. Later plantings of these inbreds were not planted at specified intervals, but the later sowings were made just as the plants from the previous one were well up so that the rows were clearly visible. We have found this method more satisfactory than making later plantings at ten-day or two-week intervals, or any other specified times. Planting dates in 1945 were May 3, May 22, June 9 and June 19. Time intervals between plantings were 19, 18 and 10 days. These intervals would differ in different years but they did give an almost continuous supply of pollen and also a continuous supply of silks just emerged.

The graphs for pollen shedding and for silk emergence are from cumulative totals. Counts were made each day of the number of tassels shedding and of the silks present. When all the silks were out, no further counts were made. However, counts of the number of tassels shedding were made each day until all plants were through shedding. This gives a good picture of the total length of time that any line was shedding pollen with the percentage of the plants shedding. For purposes of complete pollination it is probably well not to rely on the pollen from an inbred when less than 50 per cent of plants are shedding pollen. These points can be determined from the graphs.

SPLIT PLANTING OF INBREDS

In producing crossed seed of certain hybrids it is necessary to plant the inbred parents at different times. It would be highly desirable to make

Figures 19-22. Graphs showing date of tasseling and silking for planting dates May 3 (at extreme left), May 22, June 9, and June 19.

Inbreds in Figure 19 are: C3, 4, 13, 6 and 15.

Inbreds in Figure 20 are: C8, 17-1, 17-2, 35, 40, 42.

Inbreds in Figure 21 are: 22, 27, 23, 30, P39, P51.

Inbreds in Figure 22 are: 31-1, 81, 88, 53, 65, 95. June 19 planting not plotted for C65 and C95.

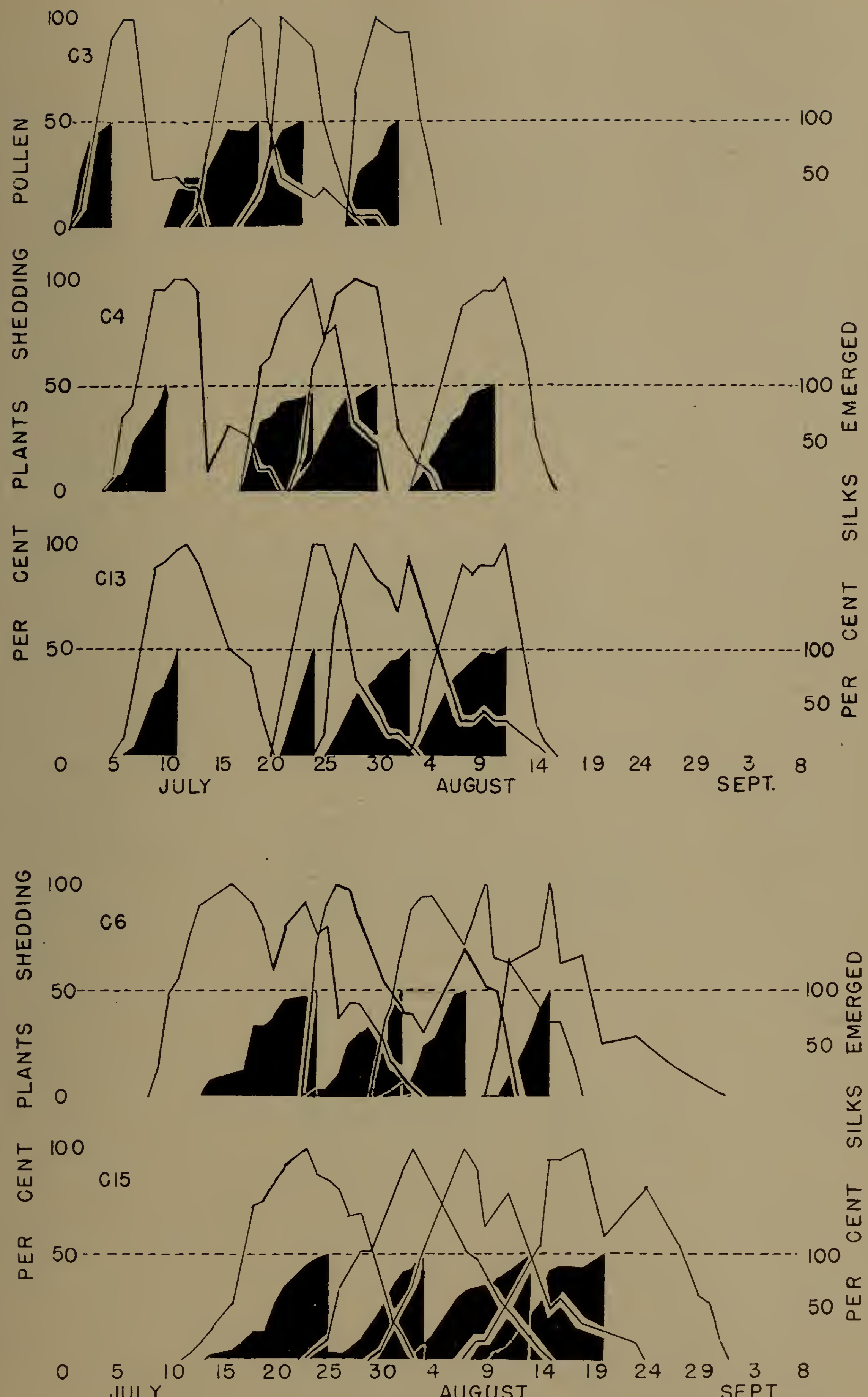

C3
C4
C13
C6
C15
PER CENT PLANTS SHEDDING POLLEN
PER CENT SILKS EMERGED
100
50
0
0 5 10 15 20 25 30 4 9 14 19 24 29 3 8
JULY
AUGUST
SEPT.

Figure 19

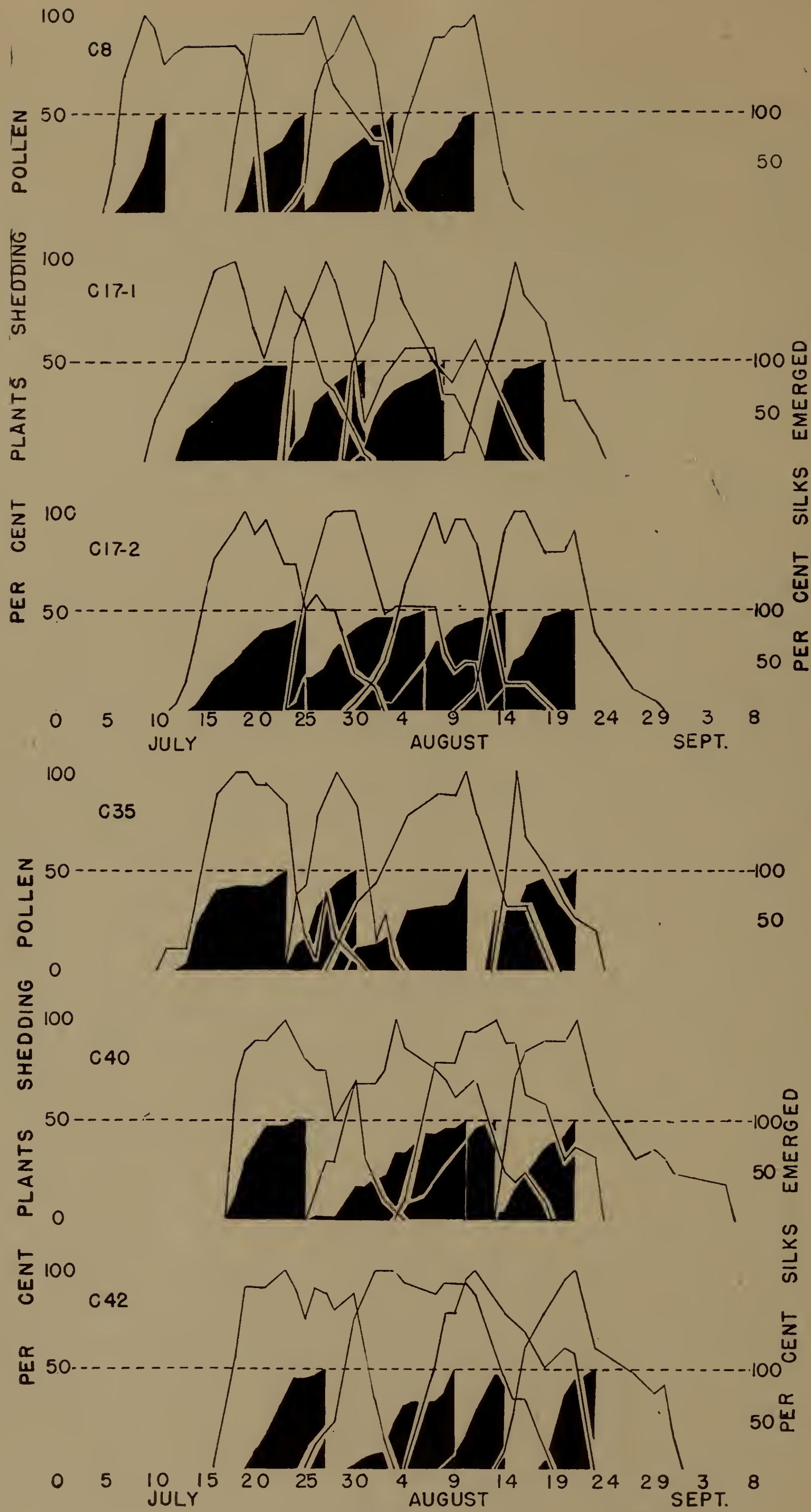

C8
C17-1
C17-2
C35
C40
C42
PER CENT PLANTS SHEDDING POLLEN
PER CENT SILKS EMERGED
100
50
0
0 5 10 15 20 25 30 4 9 14 19 24 29 3 8
JULY
AUGUST
SEPT.

Figure 20

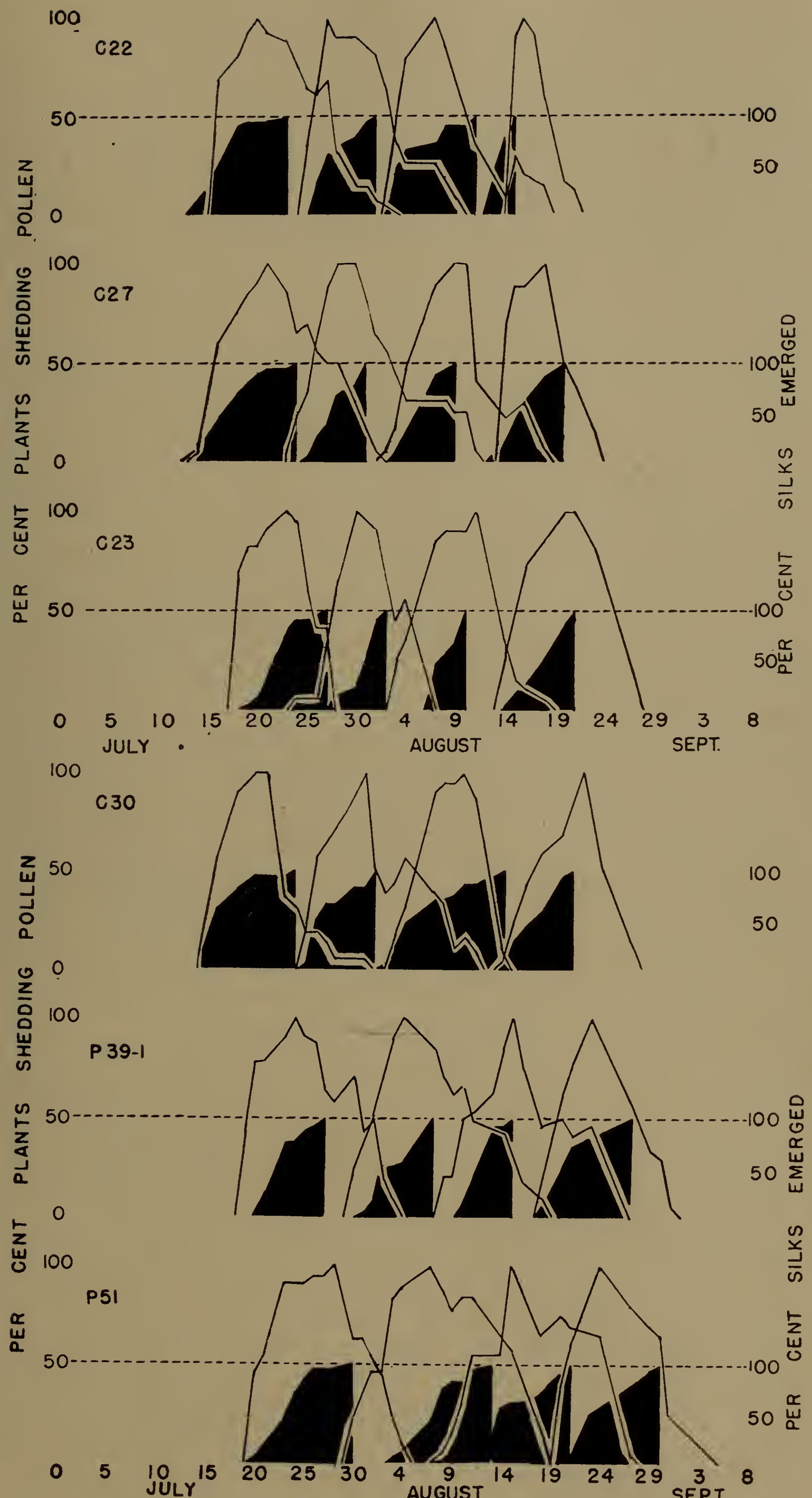
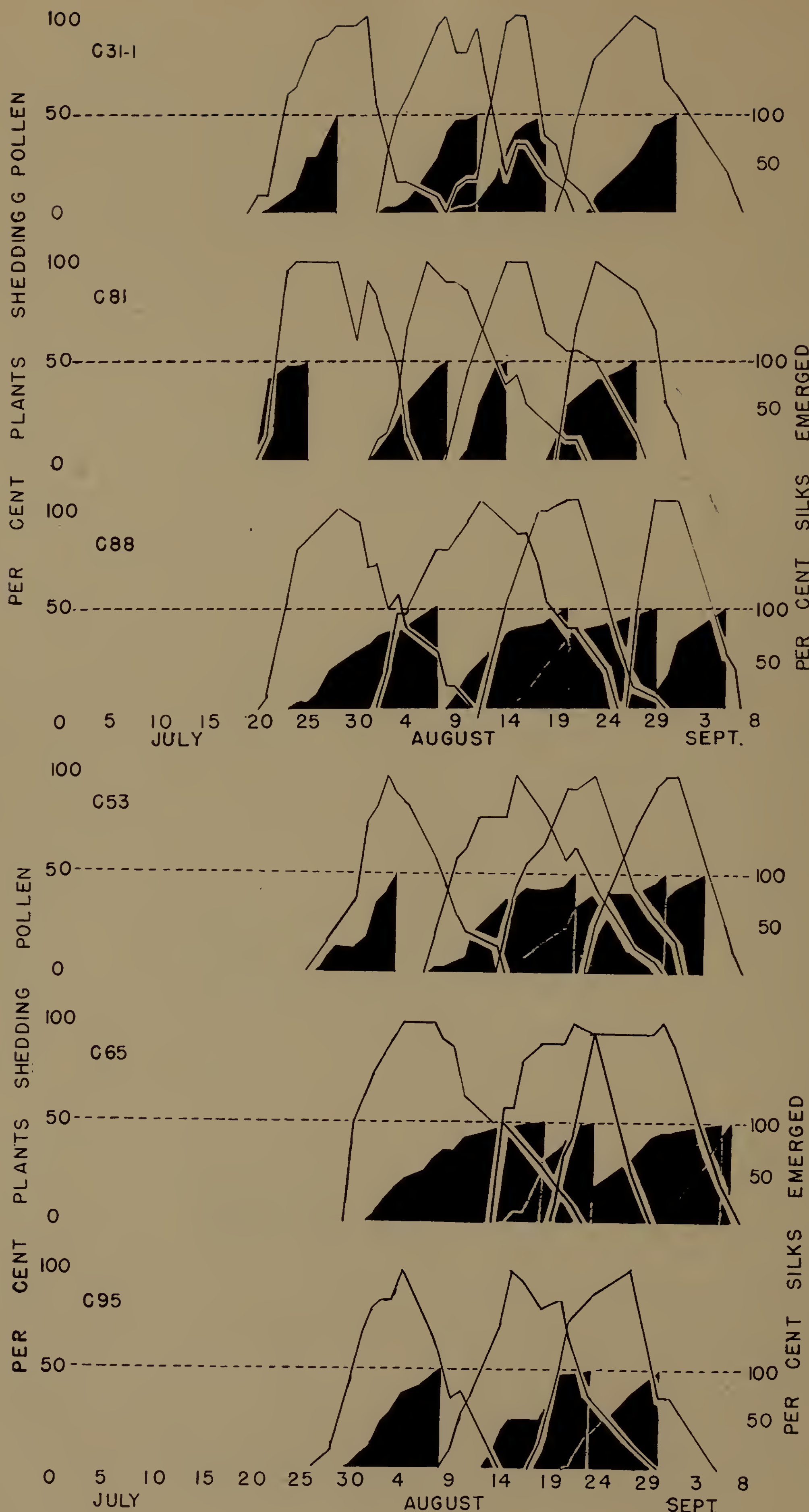

C22
C27
C23
C30
P 39-1
P51
PER CENT PLANTS SHEDDING POLLEN
PER CENT SILKS EMERGED
100
50
0
0 5 10 15 20 25 30 4 9 14 19 24 29 3 8
JULY
AUGUST
SEPT.

Figure 21



PER CENT PLANTS SHEDDINGG POLLEN
PER CENT SILKS EMERGED
C31-I
C81
C88
C53
C65
C95
100
50
0
0 5 10 15 20 25 30 4 9 14 19 24 29 3 8
JULY
AUGUST
SEPT.
PER CENT PLANTS SHEDDING POLLEN

Figure 22

only crosses of inbreds that can be planted at the same time. This is a goal well worth working for, but at the present not yet achieved. Consequently, in hybrids like Carmelcross the later parent must be planted first. By comparing the silking and tasseling dates in Figures 19 to 22 it should be possible to determine fairly accurately how much time must elapse after the late inbred is planted before the earlier one is put in. These figures will be of more use in growing sections comparable with southern Connecticut than in areas differing widely in climatic conditions, such as the irrigated sections of southern Idaho.

In making split plantings it is necessary to sow the latest inbred first, then wait until the plants are coming up so the rows are clearly visible before planting the earlier line. The reason for this procedure, rather than waiting a specified number of days, is that weather conditions play a large part in hastening or retarding the seed germination and emergence of young seedlings. As a rule the earlier in the season, the more time will be required between sowings. But since difference in growth of the plants is the thing desired it is best to let the plants themselves determine this difference. If the two inbreds used are extremely different in maturity, it may be necessary to allow more time between plantings than the procedure described above. If this is the case. it would be well to wait an extra week or 10 days before planting the early parent.

Determination of Time Between Plantings of Inbred Parents

Suppose a person were interested in producing Old Hickory and had no previous experience in producing seed of this crop. By observing the graph for C13, third planting, it will be seen that the pollen from this (the third) planting would be just right for the silks of C31-1 of the first planting. Such a pollination would produce seed of Old Hickory C31-1 x 13. Although this hybrid has given good results in years when the seed was well produced it has never been grown to any extent because the hybrid seed is so hard to produce. The C31 is usually used as the seed parent because of higher potential seed yield. However, this inbred is so tall and vigorous it is difficult to secure adequate pollination. Under such difficulties any tassels on the seed rows that may shed a little pollen before detasseling will produce a disproportionately large number of seeds not crossed. This is not condemning seedsmen who have tried to make the Old Hickory hybrid. The hybrid is so difficult to produce commercially that possibly it should never have been recommended for commercial use. Sweet corn breeders have a responsibility to the seed producers in developing hybrids that are fairly easy to produce commercially. if high quality seed is to result. We consider hybrids that require split plantings to be of a temporary nature. Eventually they will be replaced by hybrids whose inbred parents can be planted at the same time. When this is accomplished it will be much easier for seedsmen to produce a higher quality seed with a smaller percentage of seeds not crossed.

USE OF CONNECTICUT INBREDS

Table 5 shows the way the different Connecticut sweet corn inbreds are being used in sweet corn hybrids. Only the open pedigree hybrids developed at this Station are shown. The seed parents, or those considered to be sufficiently productive and having those qualities necessary in a seed parent, are listed along the vertical axis of the chart and the pollen parents listed across the top. In some cases an inbred is used in only one hybrid. Others, such as C13, are used in a considerable number. Not all of the possible crosses of

Table 5. Seed Parents (Vertical Axis) and Pollen Parents (Horizontal Axis) of Connecticut Hybrids Most Commonly Grown in 1948.

♂♂ = ♀♀ ↓	2A, 3 or 2A x 3	Golden Midget	C5	C6	C8	C12 or C13	17-1 or 17-2	C23	C27	C30	C40 or C42	Oh55	C68	C88	C95
C8	Poca-hontas	Ply-mouth													
C12 or C13	Span-cross	?	Patrick Henry	Mar-cross	Pris-cilla		Wash-ington	?	?	Carmel-cross	?				
17-1 x 17-2					++	Wash-ington		Early Lincoln	Early Lee		Early G.C.B.				
C18					?		++			?	+++				
C22						Jeffer-son	++	++	Grant	++	+++				
C31-1						Old Hickory		Big Lincoln	Big Lee		Big G.C.B.	New Wilson	++	Wilson	
C35					?	?	Walden		?		+++				
P39						Carmel-cross		Lincoln	Lee		Conn. G.C.B.	++	+++		
C53												Brook-haven		++	+++
Oh55													Pershing	Hanford	
C65												Oak Ridge			
Su Su C102.103 or T1.C103															Sweet dent silage

? hybrid not yet tested but in our opinion might make good hybrid.
++ and +++, indicate superior performance.

Figure 23. Plants of C53 x C95, one of latest sweet corn hybrids developed at the Connecticut Station. Ears probably too large for table use.

Figure 24. Ears of C53 x C95 can be eaten if one really prefers large ears.

different inbreds have been made or tested. Some of the inbreds are so far apart in season of maturity that it would not be possible to produce the hybrids economically. Consequently, there is little point in testing such hybrids. Besides the named hybrids the ones that have given good results are indicated by two or three plus (+) signs, the greater the number, the more superior the hybrid. Also a few combinations have a question mark (?) indicating such a hybrid has not been tried but in our opinion is worthy of a trial. Only the most widely used Connecticut inbreds are shown and the newer ones that have given good crosses are not listed. A list of the newer, more promising hybrids has already been given in Table 2, page 26. The newer inbreds will not be described fully in this bulletin but must await evaluation in further testing before descriptions are warranted.

HYBRID SWEET CORN SEED SURVEY

For the past several years we have conducted surveys at intervals of approximately three years to determine how much seed of Connecticut hybrids was produced. These surveys were made possible by the cooperation of the various producers of hybrid seed. No attempt was made to secure information from all the retailers of hybrid seed, but only from those who were known to be producers. There is a possibility that some small producers may have been overlooked, but probably error from this source is small. Production figures were secured from the following seed firms:

Associated Seed Growers	New Haven, Connecticut
Charter Seed Company	Twin Falls, Idaho
Corneli Seed Company	St. Louis, Missouri
The Crookham Company	Caldwell, Idaho
Farmer Seed & Nursery Company	Faribault, Minnesota
Joseph Harris Company	Rochester, New York
Huntington Brothers	Windsor, Connecticut
K. C. Livermore	Honeoye Falls, New York
Northrup King Company	Minneapolis, Minnesota
Edgar L. Oakes, Seedsman	Caldwell, Idaho
Robson Seed Farms	Hall, New York
Sleeping Giant Seed Farms	Orange, Connecticut

We wish to express our thanks to all of these firms for making available their confidential production figures. Only summaries are published in this bulletin. These summaries appear in Table 6 for the years 1941, 1944 and 1947.

The lowest line of Table 6 represents the percentage of the hybrids not developed at the Connecticut Station, but containing one Connecticut inbred. This figure shows how much use is being made of the Connecticut inbreds by commercial companies. It is gratifying to see these inbreds being used, not only in hybrids developed at the Connecticut Station, but by plant breeders in other institutions and seed companies. The inbreds were developed for this purpose.

The story told by these figures is illustrated graphically in Figure 25. It will be noted here that the drop in total amount of Connecticut hybrids is almost identical with the drop in Marcross. Most of the many new hybrids developed by seed companies are in the Marcross season. The total amount of early sweet corn hybrids is still increasing.

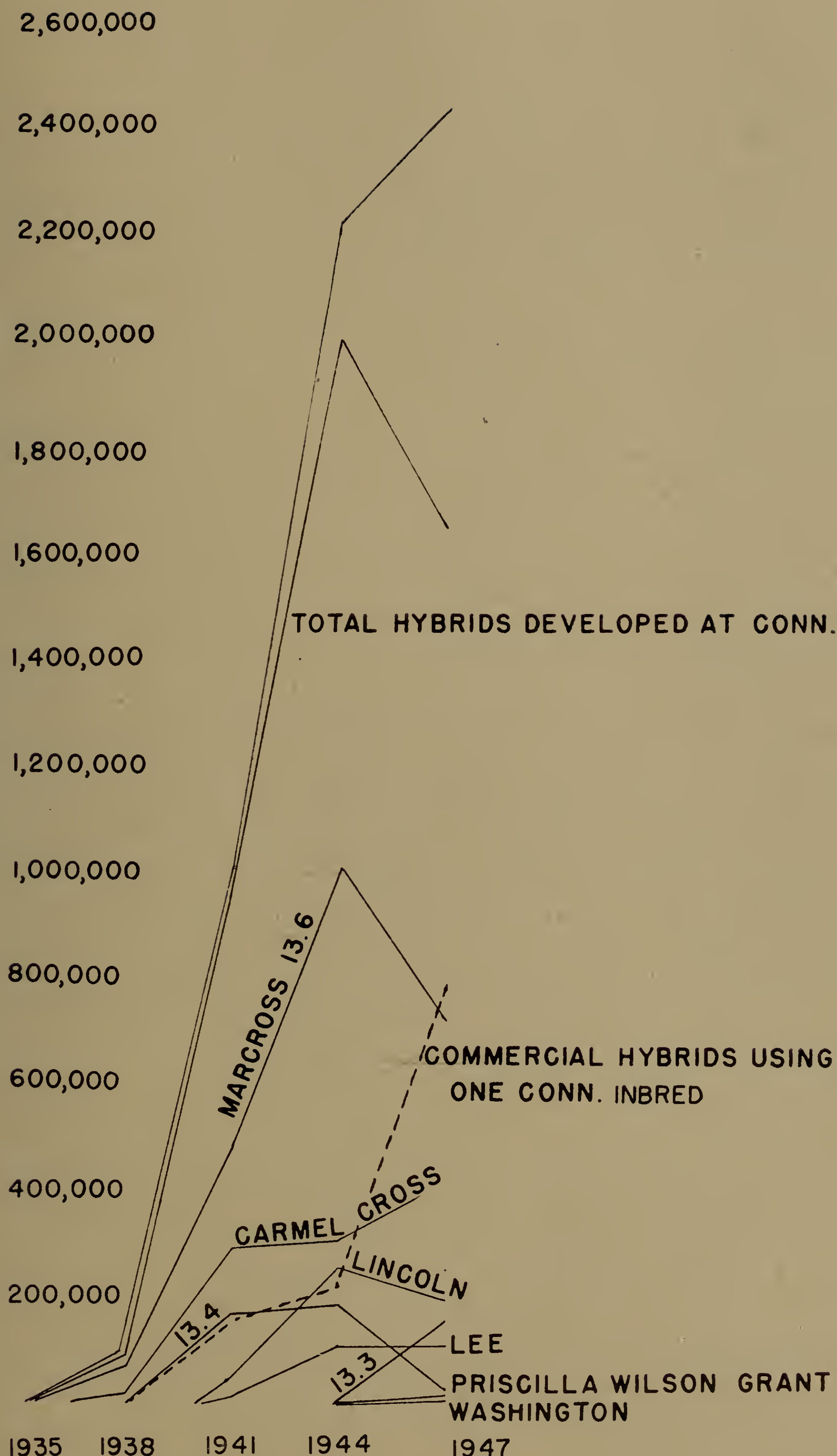


Figure 25. Pounds of seed of Connecticut hybrids produced for the period 1935 to 1947. Top graph shows grand total of all hybrids using at least one Connecticut inbred.

TABLE 6. CONNECTICUT HYBRIDS AND HYBRIDS USING AT LEAST ONE CONNECTICUT INBRED FOR THE YEARS 1941-1947.

Hybrids	1941	1944	1947
Spancross 13.3	0	0	155,000
Spancross 13.4	166,400	187,900	24,600
Marcross 13.6	486,500	1,104,300	703,400
Carmelcross(13.P39 and 13.30)	290,400	304,900	419,200
Grant 22.27	0	0	4,900
Lee P39.C27	7,000	112,000	112,400
Lincoln P39.C23	45,000	260,400	196,500
Old Hickory C31.13	0	5,000	0
Wilson C31.88	0	15,200	7,200
Other single crosses	7,000	0	5,800
Priscilla 13 x 8	0	0	9,400
Washington C13.17	0	0	6,500
Total Conn. Hybrids	1,032,300	2,004,700	1,644,900
Others using Conn. Inbreds	159,295	226,000	797,300
Grand total	1,191,595	2,230,700	2,442,200
Per cent of hybrids not developed at Connecticut but using one Connecticut inbred	13.4	10.1	32.6

MAINTENANCE OF INBRED LINES

It is axiomatic that good quality hybrid sweet corn seed cannot be produced without good inbred stock seed. Sometimes this is spoken of as foundation seed and it bears the same relationship to the final product as the foundation of a house does to the house. Everyone is agreed as to the importance of maintaining the best stock possible. There is some difference of opinion, as might be expected, as to how this job can best be done.

In the early days of hybrid corn it was supposed that once a relative degree of homozygosity was attained in an inbred, the inbred would remain fairly constant and could be maintained by hand pollination, either selfing or sibbing, or by growing in an isolated increase plot. It has been found, however, that small changes do occur and the plant breeder must be on the alert to detect such changes.

Moreover, since the inbreds are maintained for *use in hybrids* they should be continually tested for combining ability to see whether this has changed during the period. Since such testing of any number of inbreds is a considerable chore, this has not been done in the past as much as it should have been. Usually inbreds are selected on the basis of their morphological characters, trying to keep the lines as near the original type as possible. This type may not be kept clearly in mind by the plant breeder since it is not possible to preserve whole plants from year to year in their natural state. Ears may be preserved and in some cases this is done systematically. Photographs also help to keep the type fixed in mind from year to year. Even with the best safeguards some changes are almost sure to occur. The changes in morphological characters are not as important as changes in combining ability and more attention should be devoted to testing continually this point.

Sibbing versus Selfing

Most maize breeders self pollinate lines in the early generations of inbreeding to reduce to a pure line more quickly than could be done by sibbing. By sibbing we use the commonly accepted terminology meaning to pollinate a plant in a progeny by another plant in the same progeny. Some use a number of plants instead of one, a method known as mass sibbing, but one not used in our sweet corn breeding. If a considerable amount of seed of an inbred is wanted, the sibbed ears can be bulked together. This has practically the same effect as mass sibbing but individual sibbed ears can be grown separately if desired.

After an inbred has been selfed three or more years and appears homozygous, it is tested in crosses. The inbred is usually grown each year during this testing process and maintained either by selfing or sibbing. If a line seems somewhat variable, it is selfed again. If fairly homozygous, it may be sibbed. After five or six generations of inbreeding it is usually maintained in the nursery by sibbing and selfing in alternate years.

We think it is important to grow all the inbreds used commercially each year. This is not necessary to maintain a supply of stock seed since corn seed will germinate well after storage of three years. With care, good germination can be maintained for five to ten years, perhaps longer. However, each season is different from every other and by growing *all* inbreds every year there is an opportunity for some natural selection each season. Two examples might illustrate this point. In 1932 and 1933 there was a severe epidemic of bacterial wilt in southern Connecticut. Inbreds that survived those years were resistant. In 1944 there was a rather severe drouth. In that year C22 and C68 proved to be extremely drouth tolerant.

There are some who argue that laboratory means should be devised for testing inbreds for resistance to diseases and insects, drouth resistance and tolerance to a cold, wet soil. In regard to the last point it has been shown (Haskell and Singleton) (14) that by starting the germination of corn seeds at a temperature of 50° Fahrenheit under moist conditions and after two weeks transferring to a warm greenhouse, a more accurate estimate of a line's cold tolerance can be obtained than by sowing out-of-doors as early as possible. Heyne and Laude(15) have devised a method for testing drouth tolerance by subjecting seedlings to high temperatures. Young plants can be infected with bacterial wilt and stalk and ear rots by inoculation. It is more difficult to inoculate for corn smut, although this has been done.

In time improved methods of testing lines in the laboratory will be found. However, we believe these should be used in conjunction with field trials rather than to replace testing in the field. The ability of a plant to grow under continually different environmental conditions can best be determined by growing the inbred in the field. As long as an inbred line is being used commercially it should be grown in the field *each* year.

This raises the question of *where* the inbred should be grown and continued. Should it be grown where it will make its best growth or under conditions that are more rugged and offer more natural selection? We believe sweet corn inbreds should be grown under the latter set of conditions. For example, in southern New Jersey bacterial wilt and corn smut are present more often than in areas farther north. Consequently, southern New Jersey would be a better place for maintaining sweet corn inbreds and keeping them resistant to these diseases. To receive maximum benefit from such a program, *all* inbreds should be grown *each* year.

The originating Experiment Station has a responsibility to the seed grower of keeping a small seed supply of all its inbreds. All Connecticut lines are grown each year at New Haven and will be grown as long as they are generally used. Other plant breeders, we believe, follow a similar policy.

Most of the country's sweet corn hybrid seed is produced under irrigation in the Boise River Valley of southern Idaho. Growing conditions are almost ideal for sweet corn and large yields of high quality seed are obtained. However, since the conditions are so favorable, there is little opportunity for natural selection and inbreds that have been maintained there for long periods of time have changed perceptibly. For seedsmen operating in that area it is almost imperative to bring in fresh seed at regular intervals from the locations in which the lines originated, or from areas of more adverse climatic conditions. We believe such a policy as this is being carried out by the larger producers of hybrid seed. Constant vigilance is required in looking after inbred stock seed if hybrid sweet corn is to remain superior.

Shorthand System of Recording Inbred Pedigree

To keep a pedigree of an inbred and know how many generations it has been selfed or sibbed a system of shorthand has been devised. Capital letters are used to denote selfing, small letters to indicate sibbing, beginning with the letter A for one generation inbred, B two generations, etc. Thus, the pedigree C23Ec would indicate five years of selfing and three years sib pollinated. If a line is subdivided it may be desirable to show in what generation of inbreeding the division was made. Thus, C27D1A and C27D2A would indicate the C27 line was divided after four years of selfing and selfed one more year. In backcrossing programs to improve an inbred line we use the commonly accepted practice of indicating the number of years backcrossed by a superscript over the parent to which the backcrossing was done. P14.51^{2}aC would indicate that the hybrid P14.51 was backcrossed twice to P51 then sib pollinated one generation and selfed three times. In some of our breeding work it is necessary to self between generations of backcrossing. This requires a more complicated formula but one fairly easy to understand. The formula C30.HyS1 ♂ 1S2 ♂ 2S3 ♂ 3S4 ♂ 4 would indicate the cross 30 x Hy was selfed once, backcrossed once to the male, selfed twice and so on. In this

Figure 26. Inbreds C23 and C27, pollen parents of Lincoln and Lee respectively.

pedigree we use the sign ♂ signifying the word male as if it were a verb. If it is desired to shorten the above pedigree it can be done by omitting all the intermediate steps and listing only what was done, assuming that a generation of selfing followed every backcross. Thus, the above pedigree would become 30.HyS4 ♂ 4. The principal reason for using a selfed generation following a backcross is to be able to pick out recessive types from a segregating progeny to backcross to the original line. This was done in the case of the reduced mutant (found first in C30) when it was transferred to several field corn inbreds to produce a short corn. This is more fully described in another publication (16).

Getting an Inbred Line into Production

It may be well to describe briefly the method used in getting a line into commercial use. This presupposes adequate inbreeding and testing to be sure the line is ready. Seed for an isolation plot is produced by sib pollinating a large number of ears, 75 to 100, in a long row that was grown from one selfed ear. If there should appear too much variability in this long row the plants may be selfed instead of sibbed. If this is the case, the selfed ears would be grown ear to row the following year in an isolation plot. If the plants in the long row are uniform they are sibbed and the seed bulked and grown in an isolation plot the following year.

It is important to have the first increase plot well isolated since this is the foundation seed. Also 50 to 100 self or sib pollinations for further increase should be made *in* the isolation plot. There are two reasons for this. Less contamination results and there are a greater number of plants from which to select in making the pollinations. This first isolation plot must be rogued carefully for off-type plants and these, of course, should be removed before any pollen is shed. Uusually the time just before pollen is shed is a good time to remove any plants not true to type.

After the first year there will be two types of seed, hand pollinated and field pollinated. If a larger increase plot is desired the following year, the hand pollinated seed can be made to go further by using it as a pollen row with three or four seed rows from the field pollinated seed, a method proposed some years ago (Singleton 1937) (17). Our experience with this method over several years leads us to believe that the maximum utilization of the inbred seed is not the main advantage, although this is considerable. The chief advantage is that the field must be gone over several times during the critical period for detasseling and any off-type plants can be eliminated *before* any pollen is shed. Under customary methods of seed production the rogueing may not be done in time and the off-type plants are discovered *after* they have shed pollen. They are promptly removed, which dresses up the field, but does not throw out all the kernels that resulted from the pollen from the outcrossed plants. In the crossing plot method the rogueing is done at the right time, when the detasseling is done, before any silks are out. Pollen rows must be *more carefully rogued* than seed rows since the seed rows will all be detasseled and off-type ears can be discarded at harvest time. There is only one good time to rogue the pollen rows—before any pollen is shed and before silks are out.

LINE CROSSES IN THE HYBRID SWEET CORN PROGRAM

The term "line cross" is used to denote a hybrid between two sub-lines of the same inbred. There is considerable vigor in some line crosses al-

Figure 27. C17-1 and C17-2, backcrossed early lines of Purdue 39.

though not as much as when different inbreds are crossed. The rather striking vigor when two sub-strains of the same inbred are crossed has been observed by a number of geneticists and plant breeders. It has been emphasized in several Connecticut publications [Jones (18), (19); Singleton (10); Singleton and Nelson (9)] and was first advocated as a means of increasing the seed yield of inbreds in crossing fields [Singleton (11)]. Not only is the seed yield larger but also the seeds produced are somewhat larger and there is a higher percentage of flat kernels on line crosses. The quality of the seed produced on line crosses is superior to that produced by the lines as normally grown. Some of the seed companies are using line crosses as seed parents in crossing plots.

It is now a commonly accepted fact that line crosses will outyield the regular inbred parents. However, the grower wants to know if the final hybrid, made using a line cross as one parent, is as productive and as uniform as the single cross made in the conventional way. Preliminary trials indicate this to be true.

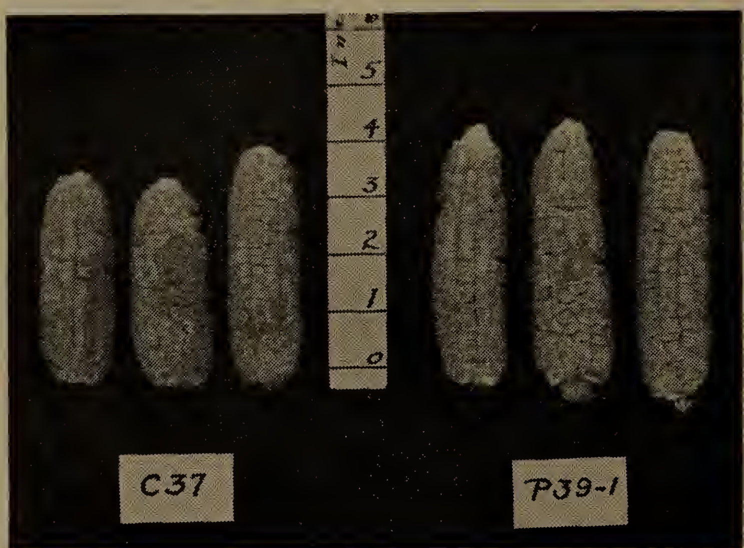


Figure 28. C37 and Purdue 39-1, Connecticut strain of P39. C37 is backcrossed P39 line.

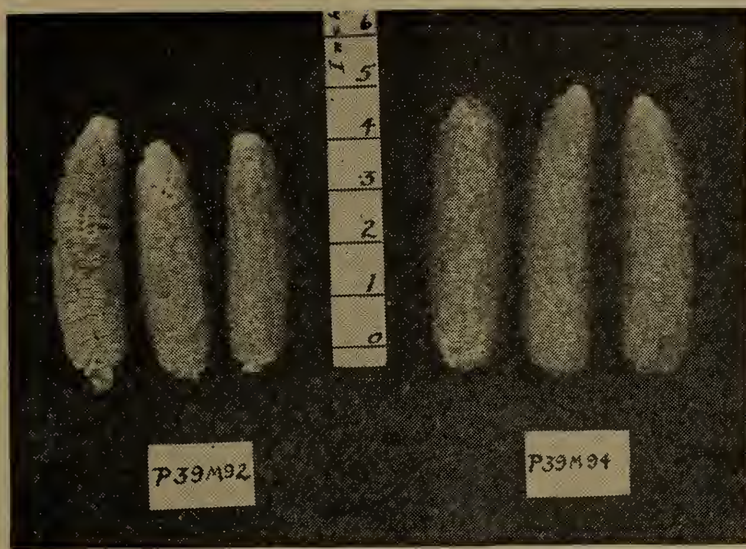


Figure 29. P39M92 and P39M94, two of most productive P39 lines.

In 1945 these six hybrids were tested for yield and uniformity: P39-1 x C42, C30 x C42, P39-1.C30 x C42, P39-1 x P51, C30 x P51 and Golden Cross Bantam P39.P51 from Robson Seed Farms, Hall, N. Y. The ears were harvested at the green stage and in addition to yield data, the individual ears were weighed and the variation within samples and between samples was calculated. Table 7 presents the data for yield and for mean variation within the plots. If the line cross hybrid (C30.P39-1 x C42) is any more variable than the straight single crosses it should be apparent from this table.

TABLE 7. YIELD AND VARIATION OF DIFFERENT SAMPLES OF GOLDEN CROSS BANTAM IN A 6 x 6 LATIN SQUARE TRIAL HARVESTED AUGUST 28, 1945

Variety	No. ears	Total wt. (with husks on) pounds	Av. wt. (with husks on) pounds	Mean variation husked ears
Golden Cross Bantam, Robson	133	92.9	.70	1272
P39-1.C30 x C42	138	81.6	.59	825
P39-1 x P51	135	78.8	.59	824
C30 x P51	121	78.8	.65	885
C30 x C42	120	71.9	.60	1851
P39-1 x C42	128	71.1	.56	837
Sig. dif. .01 level	19	11.6	.06	

It is readily seen from this table that the line cross hybrid is no more variable than the straight single crosses as far as weight of husked ear is concerned. If there were differences in size or differences in maturity they should show up in the husked ears.

The following table shows the method of calculating the mean variation. The example used is the line cross hybrid, P39-1.C30 x C42. Figures shown are for the six replications.

N (Number ears)	SX (Wt. in grams)	SX^2	$(SX)^2/N$
24	4650	932,300	900,937
24	4985	1,020,725	1,035,426
23	4170	781,850	756,039
26	4570	851,450	803,265
22	4370	880,600	868,040
21	3865	718,675	711,344
140	26610[1]	5,185,600	5,075,051
Av.	190	−5,057,800	-5,057,800
		127,800	17,251

Analyzing for variance we find the following:

Source of Variation	D.F.	Variation	Mean
Between Plots	5	17,251	3450
Within Plots	134	110,549	825
Total	139	127,800	

In 1945 a similar comparison was made between line cross hybrids and single crosses in a late series of corn. The three primarily concerned were C31-1 x C88, C31-2 x C88 and C31-1.C31-2 x C88. Yields and variation for these hybrids are shown in the following table.

Table 8. Comparison of Late Sweet Corn Hybrids, from a 6 x 6 Latin Square Trial in 1945

Yields based on barn dry ears, about 8 per cent moisture.

Variety	No. ears	Wt. lbs.	Av. wt. lbs.	Mean variance
C31-1 x 88	113	26.7	.24	749
C31-2 x 88	113	27.3	.24	906
C31-1.31-2 x 88	97	19.9	.21	811
Sig. dif. .01 level	32	6.7	.03	

Here, again, there was no greater variation in weight of the line cross hybrid. The yield of the line cross hybrid was significantly lower than the other two. This is probably due to a slightly later planting of this hybrid, seed of which was produced in the greenhouse during the winter of 1944-1945. Also, the quality of the seed used was not as good as the two single crosses. In subsequent trials line cross hybrids have yielded as well as the regular single crosses.

Since there is some evidence to indicate the variability of line cross hybrids is not greater than single crosses, considerable work has been done in determining which is the best line cross to use from the standpoint of yield and seed quality. The inbred used in this experiment was Purdue 39. It was chosen because it is the most widely used sweet corn inbred and because there is considerable difference between different strains of Purdue 39.

In 1945 several different lines of Purdue 39 were crossed by C30 and P39-1, the line of Purdue 39 that has been maintained at Connecticut since it was obtained from Dr. Glenn M. Smith when Purdue 39 was released. In 1946 these line crosses were compared in a 5 x 5 lattice design, using three replications of each one. In this trial several selfed lines of P39 were com-

[1] $\frac{26610^2}{140} = 5{,}057{,}800 =$ Correction factor (C).

pared. Yields were taken for seed produced and also for total dry matter produced. There is, as would be expected, a close correlation between these two items since the dry matter in the ears is one of the components of total dry matter. Figure 3 illustrates this point.

Table 9. Yields of Purdue Selfed Lines in Comparison with Crosses of Sub Lines of P39.
1946 data

	Variety	Total dry matter (hundred grams)	Yield of grain
1	P39M94 x 39-1	55	30
2	P39M83 x 39-1	46	22
3	P39M96 x 39-1	42	20
4	P39M92 x C30	42	19
5	P39M92 x 39-1	39	20
6	P39M96 x C30	37	18
7	P39MCC x P39M92	35	16
8	P39M94 x C30	34	18
9	P39M94 self	33	16
10	P39M96 self	31	17
11	P39M83 self	31	17
12	P39M83 x C30	31	16
13	P39-16 x 39-1	31	12
14	P39-16 x C30	30	13
15	P39MCC x P39-16	30	11
16	P39-1 x C30	29	16
17	P39 R	27	11
18	P39-9 x C30	24	10
19	P39M92 self	23	11
20	P39-1 self	23	9
21	P39M157 x 39-1	22	11
22	P39M157 self	19	5
23	P39-16 self	19	4
24	P39M157 x C30	18	6
25	P39MCC self	14	2
j.s.d.	.01 level	5	

Yields of these selfed progenies and line crosses are shown in Table 9. It will be seen that some inbreds have the ability to contribute much more than others in making a line cross productive. Six different P39 lines, P39MCC, 39-16, 39M83, M92, M94 and M96, were included in these tests, as well as their crosses with P39-1 and C30. In all cases except one, the cross of an inbred with P39-1 yielded more than the same line with C30. In one line, P39M92, the C30 cross produced more than the comparable 39-1 cross but the difference was not significant. What we first considered (Singleton 1943) (10) to be a single factor for heterosis seems now to be more than one factor. The extra vigor (in hybrids) first found in the reduced inbred C30 was most likely not due to the reduced gene at all, but to others associated with it (Singleton 1947) (20). A study of Table 9 reveals the fact that three of the selfed lines, P39M94, M96 and M83, were in the top 12 entries while the other three, P39-16, P39M92 and P39MCC, were in the last 13. We were interested to know whether the better P39 lines gave the more productive line crosses. The following association table sheds light on this point.

Inbred in Top 12 Line Cross in Top 12 6	Inbred in Top 12 Line Cross in Lower 13 0
Inbred in Lower 13 Line Cross in Top 12 2	Inbred in Lower 13 Line Cross in Lower 13 4

There is good indication that the more productive inbreds themselves did produce the better line crosses. This is not surprising. There is considerable evidence from other workers (reviewed by Singleton and Nelson 1945) (9) showing that as a rule the better, more productive inbreds produce the better yielding hybrids. It might be assumed therefore that the higher yielding line crosses would, when crossed by an unrelated inbred, give the higher yielding line cross hybrids.

Further tests are necessary with hybrids of the different P39 line crosses and the inbreds P51, C23, C27 or any other pollen parent commonly used in making hybrids with P39. Some of these hybrids were made in 1947 for testing in 1948. On the basis of results already obtained, it seems logical to expect that the better sub-lines of an inbred will produce the superior line crosses, and these in turn when crossed by an unrelated inbred, would give the highest yielding hybrids. Seedsmen who are making use of line crosses might plan their program along these lines with more hope of success than if they selected their lines for line crosses at random, or chose the less productive ones.

Figure 30. Purdue 39 (left) and Connecticut 30, reduced mutation of P39.

DISCUSSION

The purpose of writing this bulletin was to summarize the past two decades of work with hybrid sweet corn at the Connecticut Station. During that time sweet corn hybrids in commercial use have increased from practically nothing to more than 75 per cent of the total crop grown. This figure

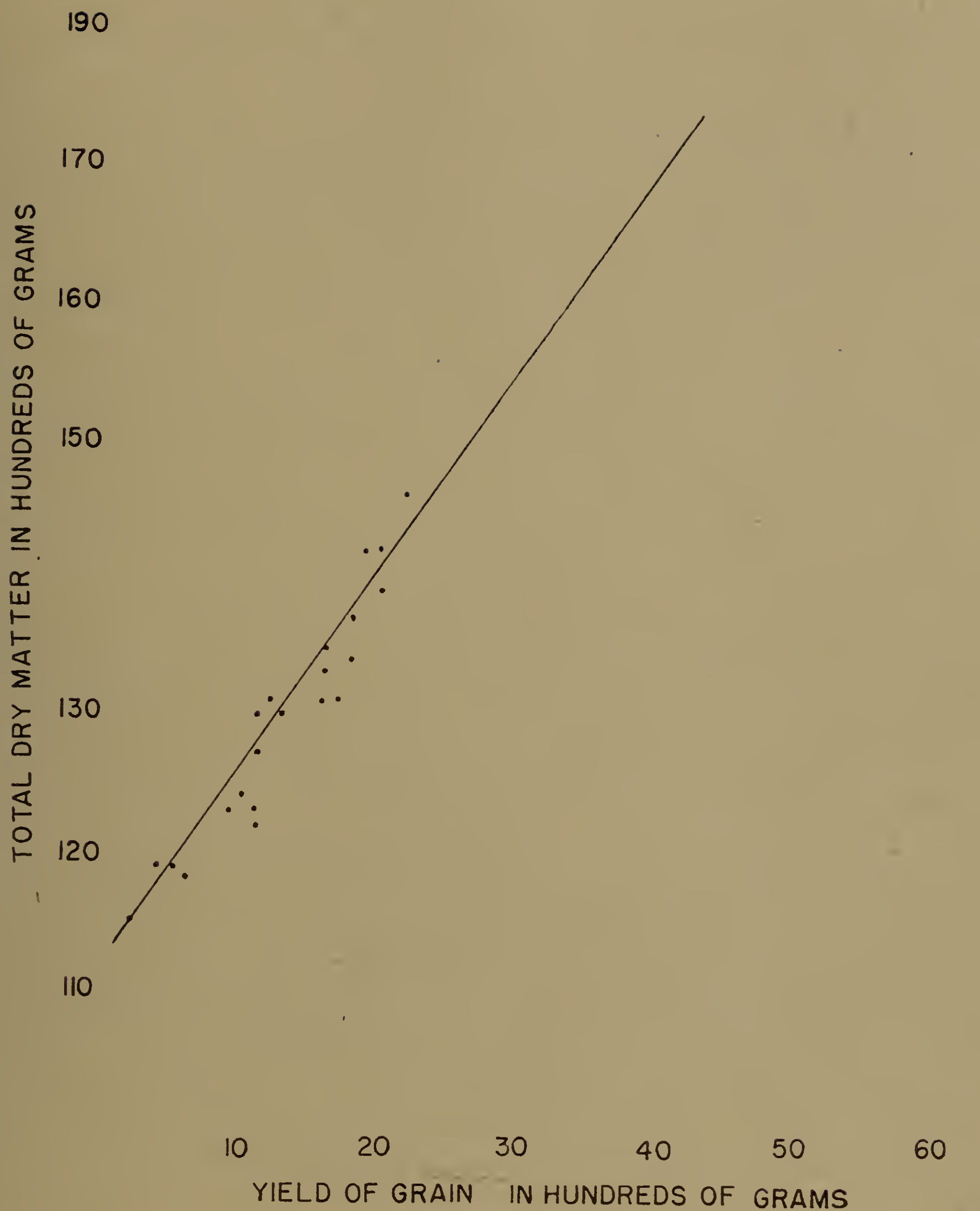


Figure 31. Yield of grain (horizontal axis) plotted against total dry matter produced. Yield figures in hundreds of grams.

would be even higher were it not for the large amount of Golden Bantam grown by home gardeners in the last few years. Although this variety is used scarcely at all commercially, it still represents about 11 per cent of the total amount of sweet corn grown. This figure is based upon the amount of seed produced, a more accurate measure of the amount grown than an estimate of the acreage. Probably the reason Golden Bantam has been used so much in the last few years is the large number of War Gardens, Victory Gardens and Freedom Gardens. In these efforts many people are taking part who have not gardened for years. When they plan their gardens and think of sweet corn, they often think of that long-popular name in sweet corn, Golden Bantam. Perhaps they have never heard of Golden Cross Bantam, Marcross or Carmelcross. This undoubtedly is part of the reason why hybrids have not replaced open pollinated sweet corn altogether, as is the case for field corn

in the leading corn states. However, the record of hybrid sweet corn is an impressive one.

We have tried to give brief descriptions of all the hybrids developed and introduced up to 1948 as well as a description of the inbreds that made those hybrids possible. In addition, the various breeding objectives that were in mind at the beginning of the program, or evolved during the course of these investigations were set down. These have been elaborated fully in the text and will not all be discussed further. Only those which have a bearing on future breeding and research should be the object of our attention here.

We have been asked just what procedure a commercial seedsman should follow in developing new hybrids. There is considerable difference of opinion among plant breeders as to which is the most efficient method. Our answer is that no single method is the best to follow. The breeder must be able to evaluate the different methods and choose the one that he thinks will be the most effective for him. If he is alert, he will undoubtedly change his methods and objectives as he goes along.

It should be emphasized that all breeding problems are far from solved and improvements in breeding techniques will undoubtedly come. Neither do we have an adequate explanation for the riddle of hybrid vigor that plays such a large part in making hybrids productive. There are theories, it is true, and these form working hypotheses. But a working hypothesis, however sound or plausible, must not be confused with proof. Much remains to be solved by future research.

In discussing the results of research or advocating a certain breeding method, one of the pitfalls is to make the mistake of over-simplification. This is done somewhat for emphasis and every teacher knows the value as well as the limitations of overemphasis. We know that we have been guilty of this. An example might be in our advocacy of delayed versus early testing (Connecticut Bulletin 490) (9). We are still convinced that testing delayed until after the third generation of inbreeding is the one we would use if developing inbreds from open pollinated varieties. One of the reasons is the lack of uniform land for testing and the limited program under which we operate. We know this method has worked in developing some good inbreds and hybrids.

Connecticut Method of Securing Inbreds

We are not prepared to state that early testing would not do a comparable job if sufficient land and help were available. For a limited program we believe the delayed testing in conjunction with the non-individual pedigree method of obtaining inbreds to be the most efficient means. This method, first advocated in Bulletin 361(1) and later elaborated in Bulletin 490(9), is known among some of the mid-western corn breeders as the Connecticut method. It is being used more each year, not only for corn but for other crops as well. Briefly, the method is an attempt to obtain a large number of homozygous lines with the least possible effort and a minimum of bookkeeping. A large number of lines, 500 to 1000, are produced by planting in hills, one line to a hill, selfing two or more ears and discarding all but one at harvest time. Thus, every ear represents an inbred line and no individual labeling is necessary. Seed from each ear can be planted in a separate hill, or se-

parate short row, and the process repeated until lines have been selfed three or four times. There is an opportunity for natural selection to operate in every generation and no attempt is made to preserve poor lines. In fact, during the process, lines are rather vigorously discarded before testing. Undoubtedly lines good in combining ability will be discarded but better ones will be saved since there is a small positive correlation between good agronomic characters and good combining ability. Literature covering this point was reviewed by Singleton and Nelson 1945(9). Arguments for this method were also presented in detail and need not be further elaborated here. We are still convinced this is a good method, and it has produced results.

Critical readers of this bulletin will say at this point "But you have used early testing and discarded lines rather heavily after being inbred only once. Also you have tested inbreds that were in the S1 generation of inbreeding". The experiment referred to was the one in which the possibilities of developing superior inbreds from hybrid ears were being explored. We admit that we did use early testing and reduced S1 lines from 161 to 42 or 26 per cent on the basis of the growth of *one row* each of the S1 lines before any test crosses were made. They were further reduced to 23, or 14 per cent of the original lot, on the basis of the growth made by the hybrid of the S1 ears crossed with P39. From this program, which started with four open pollinated hybrid ears, have come three of the best inbreds we have, as far as either agronomic characters or combining ability is concerned, C22, 68 and 69. In this case early testing was used to advantage, further emphasizing the fact that no one method is the best for all purposes.

We are not surprised that such good inbreds have resulted from selfing open pollinated hybrid ears. This we believe to be one of the best sources of germ plasm in developing new inbreds. And for this purpose it is not important whether such a hybrid ear is self or open pollinated. The good genes are still there and some more good ones may have come in from the pollen from any one of a number of plants. The important thing is that outstanding ears are selected for inbreeding. If only self pollinated ears were used to start such a program, the number of plants from which selections could be made would be much smaller and the program more limited. The four original outcrossed open pollinated hybrid ears that were selected from the sweet corn nursery in 1935 were chosen from several thousand plants. Those four open pollinated hybrid ears have resulted in three outstanding inbreds.

Figure 32. Connecticut 68, dark green, drouth resistant, productive sweet corn inbred developed by inbreeding hybrid ear.

It seems to us a sound program to look for outstanding plants and then inbreed the ears from these, regardless of whether they were selfed or open pollinated. The success of the program of inbreeding hybrid ears points to the fact that any or all outstanding sweet corn hybrids could be profitably inbred. Such a program is now underway with inbreds from Carmelcross, Old Hickory and Lincoln. This breeding project has been discussed fully in the text. An attempt is being made to take Carmelcross apart (by selfing), secure two new inbreds of the same maturity and recombine them into a productive hybrid similar to Carmelcross, but made by crossing inbreds that mature at the same time. This is a program on which more experimental evidence is needed, but the hybrid vigor of line crosses gives hope of success.

We have digressed somewhat from the early testing that was used in the inbreeding of hybrid ears. Advocates of early testing who would use this as an example of the value of early testing, would not at the same time recommend testing on such a limited scale as we did in this experiment, and we would agree that the tests used were inadequate. Undoubtedly much good germ plasm was lost in the 86 per cent of the original lines that were discarded, but much was kept in the remaining 14 per cent. It all seems to add up to this: there must have been a lot of good germ plasm in the material that started the program. Probably the chief lesson to be learned from this is that the material inbred makes more difference to the end product than the route traveled in arriving at that end.

Use of Line Crosses in a Breeding Program

The use of line crosses in the hybrid sweet corn program was discussed at some length in the text. More effort should be devoted to finding out which are the best line crosses. All the existing sub-lines of an inbred like Purdue 39 should be tested to see which combination produces the most productive and desirable line cross. More tests are also needed to determine whether the most productive line cross of P39 will give the best Carmelcross, Lincoln, Lee and Golden Cross Bantam when crossed by C13, C23, C27 and P51, respectively. Preliminary results indicate that the better sub-lines will produce the better line crosses, and there are theoretical grounds to believe that the best line crosses would give the superior hybrids when crossed by unrelated lines. Here, again, more evidence is needed.

It is hoped the reader has gained the impression there is still much to be done in sweet corn breeding and research. One of the problems that will probably be most productive of results is research on sweet corn quality. Inbreds differ widely in their ability to make sugar and to hold this upon storage, in pericarp toughness and in flavor. Varieties differ widely in the length of time that the kernels remain in the prime condition. Some pass through the edible stage very quickly. Others, particularly the Evergreen types, will remain in good condition a longer time.

Improvements will undoubtedly come in cold and drouth tolerance, also in insect and disease resistance. Better methods of testing and inoculations need to be worked out. With more research along these lines sweet corn can be made into a crop better adapted to a wide range of environmental conditions. Another improvement might come in developing hybrids that have a high percentage of sucrose in the juice of the stalks. It has been shown (Singleton, 1948) (21) that the field corn inbred C103 contains much sucrose in the stalk. The stalks analyzed had produced good ears. This line is starchy

and considerable time is necessary to transfer the sweet stalk of the C103 to sweet kerneled inbred lines, and at the same time preserve the original quality of the sweet inbreds. It is being undertaken.

This brings up another point upon which there is considerable difference of opinion among sweet corn breeders, i.e. the use of field, *Su,* inbreds as a source of germ plasm for contributing some specific character such as a stiff stalk, dark green color, or drouth resistance to sweet corn inbreds. The sweet seeds, *su,* differ from *Su* lines in one primary factor differentiating *Su* and *su.* However, so many other factors are brought in at the same time as the *Su* gene that it takes time and effort to recover the original quality present in the *su* line. For this reason most sweet corn breeders are a little hesitant about outcrossing *su* inbreds to *Su* lines.

Among *su* lines themselves there are tremendous differences in quality, as there also are in combining ability. The question often arises in a breeding program whether it is better to concentrate on quality more than combining ability oı vice versa. Since inbreds of unusual combining ability seem to us to be more rare than good quality lines, it seems the proper procedure to concentrate on combining ability first. After a good inbred is obtained, the quality can be improved without loss of combining ability in a backcrossing program. Such a program is now under way with C22.

Some of the problems the sweet corn breeder of the future will tackle and solve have been set down. Solution of these problems will disclose others that demand solution. With biological material that is constantly changing there is no reason to expect that a final solution will ever be achieved.

SUMMARY

The hybrid sweet corn program at the Connecticut Experiment Station for the years 1924 to 1948 is analyzed and appraised in this bulletin. The various breeding objectives during this period are reviewed. These are listed below:

1. Determine feasibility of pure line method. Redgreen, Crossgreen and Greencross set new standards of uniformity and productivity. In so doing they aroused much interest in the pure line method of producing hybrid sweet corn although they did not establish definitely its feasibility. This was done by Golden Cross Bantam, a hybrid developed by Dr. Glenn M. Smith(8) of the Indiana Experiment Station and the United States Department of Agriculture. The productivity, disease resistance and good quality of Golden Cross Bantam established beyond question the superiority of the pure line method, first proposed by Dr. George H. Shull in 1909(6).

2. Develop early market hybrid resistant to bacterial wilt. This was achieved in the development of Marcross C13.6.

3. Develop a series of hybrids ripening at regular intervals for a period of approximately a month. First three hybrids in this series were Spancross, C13.4; Marcross, C13.6, and Carmelcross, P39.C13 or C13.C30. Other hybrids produced later to complete this series were Grant, C22.27; Lincoln P39.C23, or Lee, P39.C27; Golden Cross Bantam P39.P51, mentioned previously; Wilson C31.C88 or C31.Oh55, and Brookhaven C53.Oh55. The succession is now complete but improvements can be made in the quality, and perhaps other characteristics. As improved varieties are introduced they can be substituted for some of the current ones.

4. Determine the earliest generation of inbreeding in which it is possible to test for combining ability. This study (Bulletin 490) (9) showed it is not practical or advisable to test for combining ability before the third generation of selfing. Lee and Lincoln were produced in the course of this investigation.

5. Study the use of "line crosses", the cross of two sub-lines of the same inbred, in the hybrid sweet corn program. The conclusion reached from this study is that line crosses can be used profitably as seed parents in producing sweet corn hybrids. Such hybrids made with line crosses as one parent are as productive and no more variable than conventional single crosses. Seed yields of line crosses are from 10 to 20 per cent greater than the inbreds themselves. The bearing of these findings on the interpretation of heterosis is discussed.

6. Determine feasibility of taking a hybrid apart by selfing and recombining two new inbreds to form a similar hybrid. The inbred parents of Carmelcross, P39 and C13, are so different in maturity that seed production is somewhat difficult. If this hybrid can be selfed and two new inbreds that mature at the same time produced, the seed production difficulties of Carmelcross can be overcome. The project is not complete but the hybrid vigor of line crosses leads us to believe it will be successful.

7. Hybrid ears were investigated as a source of germ plasm for new inbreds. Original hybrid ears were open pollinated in sweet corn nursery. From four such ears have come three of our best inbreds. C22, 68 and 69. Hybrid ears should be used more widely as a source of new inbreds.

Possibilities for future work in sweet corn breeding are discussed. Sweet corn quality is a productive field of investigation, also insect and disease resistance, cold and drouth tolerance.

Maturity in sweet corn is discussed. Number of days from planting to ripening to indicate maturity is only of comparative value. As a designation of maturity, number of days is obsolete and should be superseded by a statement of the maturity season or a comparison with a variety of known maturity.

The historical system of nomenclature for sweet corn hybrids is now in use at the Connecticut Station. Names are chosen from American history, the earlier the historical name, the earlier the variety. Patrick Henry C13.5 is early, Lincoln P39.C23 is midseason, while Wilson is late and Oak Ridge C65.Oh55 is very late.

The various sweet corn hybrids produced and introduced between the years 1924-1948 are described. The ones now being grown commercially are Spancross 13.3, Marcross C13.6, Carmelcross P39.C13 and C13.30, Grant C22.27, Lee P39.C27, Lincoln P39.C23, Wilson C31.C88, Purplecross C69.38, Washington C13.17 and Priscilla C13.8. These hybrids represent approximately 20 per cent of all hybrid sweet corn seed produced in 1947. Of the hybrids maturing before Golden Cross Bantam, Connecticut hybrids comprise more than 75 per cent of the total. This figure will be reduced as varieties developed by commercial seedsmen are being grown in increasing quantities each year. Nearly all early commercial varieties have Connecticut 13 as one parent.

New experimental hybrids, not yet produced commercially but which may soon be, include the following: Pocahontas C3 x 8, Plymouth C8 x Golden Midget, Patrick Henry C13 x 5, Jefferson C22 x 13, Walden C35 x 17, Rutledge C35 x 81, Golden Spike C68 x P39M92, Pershing C68 x Oh55, Oak

Ridge C65 x Oh55, Brookhaven C53 x Oh55, and Hanford Oh55 x C88. These vary in maturity from very early (Pocahontas) to very late (Oak Ridge, Hanford and Brookhaven).

Methods of testing sweet corn hybrids are discussed. These fall into three categories, observation trials, quality tests and yield trials. In the first two tests only one row is grown and data obtained are of a descriptive nature. In the yield trials the most common statistical design is a 6 x 6 latin square in which small differences can be detected. The 5 x 5 lattice design has also been used.

The Connecticut inbreds that are being used or have been used in hybrids are described. These are numbered from 1-100, the lower the number, the earlier the line. The Connecticut inbreds numbered in this series are C2 (discontinued), C2A, 3, 4, 5, 6, 7 (discontinued), 8, 9, 11, 12, 13, 15, 17-1, 17-2, 18, 22, 23, 27, 30, 31-1, 31-2, 35, 36, 37, 38, 40, 41, 42, 50 (discontinued), 53, 63 (discontinued), 65, 69, 78, 81, 88 and 95.

Maintenance of inbred stock seed and its importance to the hybrid program are discussed. Under the heading "Discussion", different breeding techniques are dealt with, also breeding problems for the future. Although great increases have been made in the general use of hybrid sweet corn, many problems await future research for their solution.

Acknowledgements: We are grateful to Miss Nancy Rhynedance for help in collecting the data for Figures 19-22, also to Miss Marjorie Giefel for preparation of those figures as well as other graphs in the bulletin.

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